

DOCUMENTED BRIEFING

RAND

Options for Managing the Army's Arsenals and Ammunition Plants

*W. Michael Hix, David Oaks, Bruce Held,
Edward Keating, Michael Hynes,
John R. Bondanella*

Arroyo Center

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20041208 003

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*Prepared for the
United States Army*

Arroyo Center

DB-353-A

The research described in this report was sponsored by the United States Army under Contract No. DASW01-01-C-0003.

ISBN: 0-8330-3062-0

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Published 2003 by RAND

1700 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138

1200 South Hayes Street, Arlington, VA 22202-5050

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PREFACE

This research was undertaken by RAND's Arroyo Center at the request of the Assistant Deputy Chief of Staff for Operations and Plans (Force Development). This report provides the results of research conducted during the second phase of the project. In July 2000, we provided the sponsor a Phase 1 report, which recommended reductions in the equipment and manufacturing space footprints of two arsenals: Watervliet, N.Y., and Rock Island, Ill. Those reductions are under way.

In this report, we expand our scope to all 16 of the Army's arsenals and ammunition plants included in the study. Much of our effort during this phase was devoted to development of a broad range of options for managing this base. Here, we describe and assess qualitatively four broad options for these 16 activities: privatizing, divesting through creation of a Federal Government Corporation (FGC), consolidating on a smaller number of installations, and, finally, recapitalizing onto a smaller number of enduring multifunctional installations. The report includes two significant appendixes, important in their own right. One compares the Army's requirements for ordnance materiel with manufacturing capacities and the size of the market for such materiel; the other critiques the Army's process of developing requirements for such materiel. A third appendix assesses the Armament Retooling and Manufacturing Support (ARMS) program.

At the direction of the Study Advisory Group, this interim report describes and assesses options qualitatively but stops short of making recommendations. The phase of the research reported here was completed in November 2001. A third and final phase of the research is being published contemporaneously with the volume at hand as *Rethinking Governance of the Army's Arsenals and Ammunition Plants*, RAND MR-1651-A, 2003.

This study should be of interest to policymakers, resource managers, and others concerned with the sizing of the Army's industrial base.

This research was initially sponsored by the Assistant Deputy Chief of Staff for Operations and Plans (Force Development), U.S. Army. That office, with the sponsorship of this study, was transferred to the Deputy Chief of Staff for Programs, recently redesignated the G-8. The research was carried out in the Military Logistics Program of the RAND Arroyo Center, a federally funded research and development center sponsored by the United States Army.

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SUMMARY

BACKGROUND AND PURPOSE

The Army has a large installation base, much of which has been shaped by demands that no longer exist. For example, much of today's installation structure was determined by the mobilizations the nation went through to fight two World Wars. In particular, the Army's existing arsenals and ammunition plants are operating at a fraction of their capacities. As a result, in the fall of 1999 the Office of the Secretary of Defense directed the Army to prepare a report on the right sizing of these facilities.

At the request of the Assistant Deputy Chief of Staff for Operations and Plans for Force Development, RAND's Arroyo Center undertook this study on behalf of the Army. An earlier report delivered findings about the Watervliet and Rock Island arsenals. This report expands its focus to include all 16 arsenals and ammunition plants.

CURRENT STATUS

The 16 installations studied fall into five classes of production: (1) ordnance items, such as gun tubes and gun mounts manufactured at the government-owned, government-operated (GOGO) Watervliet Arsenal, N.Y., and Rock Island Arsenal, Ill.; (2) metal parts manufactured at the government-owned, contractor-operated (GOCO) Louisiana Army Ammunition Plant (AAP), La.; Mississippi AAP, Miss.; Riverbank AAP, Calif.; and Scranton AAP, Pa.; (3) load, assemble, and pack (LAP) operations of a special nature conducted at the GOGO Crane Army Ammunition Activity, Ind.; McAlester AAP, Okla.; and Pine Bluff Arsenal, Ark.; (4) other GOCO LAP operations at Iowa AAP, Iowa; Kansas AAP, Kan.; Milan AAP, Tenn.; Lone Star AAP, Tex.; and Lake City AAP, Mo.; and (5) propellants and explosives at the GOCO Radford AAP, Va., and Holston AAP, Tenn.

The installations range in size from Crane Army Ammunition Activity, housed on a Navy-owned installation of more than 50,000 acres southwest of Bloomington, Ind., to Scranton AAP on 15 acres of land in the heart of Scranton, Pa.

The activity level at 10 installations for which historical data are available is relatively low. None of the installations employs more than 20 percent of its peak employment level. The time of the peaks varies from installation to

installation; some occurred during World War II, others during the Korean War or Vietnam era. At any rate, the current low levels provide some rough indication of the excess land and facilities now available at these plants. They also indicate the availability of a hedge against any future increases in requirements. But trends toward greater reliance on precision munitions and better target acquisition systems are likely to drive conventional ammunition requirements lower rather than higher.

In addition to the installations named, 11 other ammunition plants remaining on the Army's books have been declared excess—10 declared excess outside of Base Realignment and Closure (BRAC) process and one closed as a part of the process. The disposal process is slow, taking an average of 12 years to dispose of the last pieces, stemming principally from Army practices of environmental remediation.

Army Materiel Command is in the process of executing long-term (5- to 10-year), firm fixed-price supply contracts with ammunition producers. The firm fixed-price feature of the policy is intended to reduce costs by providing incentives for producers to become more efficient. Long terms of the contracts make it more attractive for firms to invest in productivity-enhancing capital. At the same time, the Army has begun entering into longer-term (25-year), facilities-use contracts with ammunition suppliers. This stability enables the contractors to attract commercial tenants to their installations. Tenant revenues can offset the costs of plant ownership. The Armament Retooling and Manufacturing Support Act of 1992 (commonly referred to as the ARMS Act) supports this concept by authorizing a program under which funds are appropriated to permit infrastructure investments to attract commercial tenants. Recent legislation has extended the Act's authority beyond ammunition plants to arsenals. While these long-term contracts may have economic benefits, they raise the cost of and impede progress toward divestiture of unneeded plants.

REQUIREMENTS

Current policies require ordnance materiel for two purposes. First, some materiel is required to satisfy programmed buys—for training and for possible use in the two major theater wars (MTWs) that represent the current national military strategy. Second, materiel is needed to replenish stocks consumed during the two theater wars. The second is a contingent requirement in that replacement materiel will be procured only if the two theater wars occur. Current policy calls for replenishing expended stocks to provide a one-MTW inventory. Policy requires such ordnance items as gun

mounts and cannon to be replenished within three years. It specifies no period for replenishing ammunition.

Prudence dictates that the nation be able to meet not only today's requirements but also future ones. Gauging future demand is difficult, and decisions affecting future capability should be made cautiously. Because it cannot be known with certainty what those future requirements may be, it is appropriate to maintain a hedge against plausible future demands. The Army need not maintain such a hedge with organic capabilities and capacities. Privately owned facilities can serve that purpose.

The Army's process for determining replenishment requirements is slow. It takes more than two years for the Army to translate the outcomes of its biennial analysis, called the Total Army Analysis, into a production base plan for replenishment. This lengthy process ensures that replenishment planning is chronically out-of-date. Most of the two years elapsed time is taken by the Army Staff and the Army Materiel Command.

Further, the analysis is built on generous assumptions that inflate the estimated requirement. For example, the analysis assumes that all ammunition sent to the theaters of conflict is either expended or is no longer serviceable. None is assumed to be returned to the United States for later use. Further, it is assumed that none of the ammunition that remained in the United States during the two MTWs is later available for post-MTW use. Third, it is assumed that neither the arsenals nor the ammunition plants begin replenishment operations until the two MTWs are terminated. This shortens the effective time available to replenish within a fixed replenishment period—now three years for such ordnance items as gun tubes and gun mounts. A shorter replenishment period means higher required production rates. Further, policy calls for replenishing a single MTW's worth of ordnance materiel. The Army arrives at this one-MTW figure by taking the highest expenditure for each ammunition item regardless of the theater in which it occurred. In other words, if MTW 1 had the higher expenditure of tank ammunition and MTW 2 had the higher expenditure of artillery ammunition, the requirement would be derived from summing these two expenditures as well as the higher expenditure for every other ammunition item. The resulting requirement is far larger than the consumption of a single MTW.

Third, the process yields highly variable requirements each time the biennial analysis is conducted. The variance is due, in large measure, to changing scenarios and assumed operations plans. For example, one year MTW 1 might go first; the next time, MTW 2 might go first. Further, one

year certain types of highly effective munitions may be assumed to be delayed in fielding, thereby raising the requirement for munitions of lesser effectiveness. Although this variance may be inevitable, it does imply that decisionmakers should not base irreversible production base decisions on any one year's statement of requirements. The stated requirements are unstable and the variance is often large.

Despite the variance in stated requirements, there exists substantial capability and capacity to replenish, well within three years, all the gun mounts and cannon necessary to meet even the highest statement of requirements and all but 22 of 455 ammunition items. Since production base planning generally assumes single-shift operations during replenishment, the ability to step up to more than one shift in effect multiplies the potential capacity, substantially reducing any replenishment risk.

We offer two recommendations for improving the process by which replenishment requirements are developed. First, we recommend that an ad hoc Headquarters, Department of the Army, review panel assess the assumptions that underpin the resulting requirements. Second, we recommend that this panel seek ways to streamline and accelerate the process.

PRINCIPLE UNDERPINNING THIS ASSESSMENT

Our assessment takes as an underlying principle the imperative to rely on the private sector for provision of the items at hand unless other considerations dictate the contrary. A presumption of the inherent superiority of private ownership of capital underpins generally accepted principles of cost-benefit and related economic theory. These principles are codified in several statutes.

First, 10 USC 2501 requires that the national technology and industrial base meet its various objectives by "relying to the maximum extent practicable, upon the commercial national technology and industrial base . . ." and "reducing Federal Government barriers to the use of commercial products, processes and standards."

Second, 10 USC 2535, which deals with ensuring an adequate defense industrial reserve provides for an essential nucleus of government-owned plants. This law complements 10 USC 2501 by asserting the intent of the Congress "that to the maximum extent practicable, reliance will be placed upon private industry for support of defense production." The statute goes

on to say that machine tools and equipment not available in the private sector but needed in time of national disaster may be held in plant equipment packages (in commercial plants) or in a general reserve.

Often cited as conflicting with 10 USC 2501 and 2535 is 10 USC 4532, the Arsenal Act, which requires the Secretary of the Army to "have supplies needed for the Department of the Army made in factories or arsenals owned by the United States, so far as those factories or arsenals can make those supplies on an economical basis." But the statute also states that the Secretary of the Army may "abolish any United States arsenal that he considers unnecessary." In the context of the options under consideration in this study, no conflict is apparent between the Arsenal Act on the one hand and the other two statutes on the other. The Arsenal Act explicitly grants the Secretary of the Army the authority to abolish any arsenal he deems unnecessary. Hence, for the purposes of this study, which involve deciding what capabilities the Army needs to continue to own, the Act presents no barrier to privatizing, consolidating, creating a Federal Government Corporation (FGC), or recapitalizing. Once those actions are implemented, the Act governs decisions related to any remaining arsenals or factories.¹

Four countervailing considerations exist for the mandate to rely on the private sector. Any one of these factors provides justification for the government to conduct manufacturing in its own factories or arsenals rather than relying on the private sector.

First, the government may not outsource inherently governmental functions. OMB Circular A-76² specifically cites the manufacture of ordnance equipment as a commercial rather than inherently governmental activity.

Second, the government may need to own manufacturing operations if no commercial producer can be induced to supply needed goods.

Third, the government may need to own assets and employ a workforce to ensure continued availability of important capabilities and capacities, particularly in time of crisis. This logic, of course, if applied to the entire

¹The wording of the Arsenal Act, "factories or arsenals," appears to be universally interpreted to include Army ammunition plants as well as the arsenals. Hence, the statute applies to all the activities at hand in this phase.

²U.S. Executive Office of the President, Office of Management and Budget, *Circular Number A-76, Subject: Performance of Commercial Activities*, August 4, 1983 (Revised 1999), p. 2 and Attachment A.

range of Defense needs, would lead to federalization of all Defense manufacturing for which urgent, unforeseen requirements might arise, and that would, of course, apply to a large proportion of all the Defense Department procures. It is also argued that privatization of GOGOs or even GOCOs risks the loss of these assets should their commercial owners go out of business. Yet, most of what the Defense Department procures is manufactured in commercial rather than Defense-owned factories.

The Army is unique among the services in its philosophy of continuing to own factories. All Navy ships are now built in commercial facilities, most of them one-of-a-kind and economically incapable of building other types of vessels. Similarly, the Air Force owns no GOGO factories and is divesting of its remaining six GOCO factories. And, in the remaining six, contractors own the equipment; the Air Force owns only the land and buildings. Privatization need not risk loss of unique or needed assets. Just as the Army ensures that its organic capabilities remain intact, it must continue to ensure the continued viability of any required assets it privatizes. Relying on the private sector does not imply that the Army can ignore the commercial base. The services have a responsibility to ensure that essential private capabilities are maintained, and that requires careful management of procurement and application of financial incentives to ensure the health of the private base.

Finally, it can be appropriate for the government to own assets and employ a workforce if it is inherently more efficient than the private sector in producing goods. Particularly in the GOGO arsenals, high direct labor charges have been the cause of much consternation. It is true, however, that at GOGO installations where a fixed workforce is underemployed, manufacturing can be done at low marginal costs relative to a private firm whose short-run variable costs include labor. But the prior question that this study considers is whether in the long run these GOGO facilities will be economically competitive. The relative efficiency of the options described in this report remains to be demonstrated.

OPTIONS FOR CHANGE

Despite the uncertainty and variance surrounding the requirements process, the options described below may be pursued without waiting for the process to improve. Such is the case because all these options permit the Army to meet any plausible range of requirements. The analysis indicates that the key to improving the production of ordnance items lies in changing governance of the base.

The analysis suggests four options in addition to the status quo. They are:

- Privatize to divest peripheral functions and harness private incentives
- Create an FGC to divest government functions and retain government control
- Consolidate to achieve a more efficient base
- Recapitalize and unify to meet new demands and to achieve efficiencies.

Privatizing means divesting the installation of the means of production and simply buying the products from private firms. The option permits consolidation of any assets considered inappropriate for privatization onto a smaller number of installations, but the imperative underpinning of this option is to privatize.

Creating an FGC transfers production assets to a congressionally chartered FGC. Implementation options would permit either the Army or the FGC to consolidate and divest unneeded assets. Because of its entrepreneurial freedom and bottom-line incentives, the FGC could be expected to find broader uses for the plants, equipment, and land than the Army does today.

Consolidating attempts to restation functions on as few of the current set of properties as possible, divesting the facility of unneeded land, buildings, and equipment, thereby saving base support costs and achieving economies of scale in manufacturing by collocating manufacturing operations. The remaining plants continue to operate on single-function installation as they do today.

Recapitalizing and unifying the base is driven by two assumptions, namely that, in the long run, new manufacturing technologies will be required and the Army will want to get out of small, single-function installations and consolidate onto more enduring, multifunctional installations, perhaps multiservice ones. Recapitalization may or may not result in consolidation of these manufacturing operations. It will, however, mean that manufacturing will no longer be accomplished on stand-alone ammunition installations.

The qualitative assessment involved weighing the options against a criteria set approved by the Army. It included the six criteria listed in the figure. The criteria do not all carry equal weight. Mission fulfillment is the most important, and any option that poses a substantial risk to the production of items programmed or later required during replenishment following two MTWs would be at a distinct disadvantage relative to options lacking such

Pure Strategies: Preliminary Comparative Assessment					
Assessment Criteria	Options				
	Status Quo	Privatize	Create FGC	Consolidate	Recapitalize
Mission Fulfillment <small>Programmed requirements Replenishment Responsiveness Certainty of capability Technology advancement</small>	All options retain necessary capacity—programmed and replenishment Privatizing <i>could</i> reduce the certainty of capability—<i>must manage</i> Recapitalizing enhances responsiveness and advances technology				
Financial <small>Net present value Revenues Operating Costs Transition</small>		Best in long run	Bottom-line incentives	Could recapitalize	Achieves efficiencies (Gov't)
Managerial Ease <small>Workforce management Process management Entrepreneurial flexibility Access to capital</small>		Best	Almost as good	Little help	New processes
Statutory Compliance <small>10 USC 2501 10 USC 4532 10 USC 2535</small>		Only option that helps			
Regulatory Consistency <small>AR 700-90 Policy Letter 98-1</small>		Only option that helps			
External Issues <small>Congressional support Union and job concerns State and local politics</small>		GOGO difficult	Unknown. Perhaps easy	GOGO difficult	Most difficult

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risks. The six major criteria each have subordinate criteria, listed in the second column of the figure.

The lightly shaded boxes indicate the best option by that criterion; the darker boxes indicate the least desirable option.

Mission fulfillment consists of five subordinate evaluation criteria: ability to meet programmed and replenishment missions, ability to respond rapidly to unforeseen demands, the certainty that needed capacity will remain available when needed, and the extent to which the option will foster the inclusion of advanced manufacturing technology. We assess all five options, including the status quo, as having roughly equal likelihood of meeting both programmed and replenishment demands. While privatizing all or part of the base would have the potential to reduce capacity and therefore inhibit the ability to meet demands, we feel that the privatized base can be managed in ways that ensure needed capacity. We note that all Navy ships are manufactured in completely private yards that the Navy manages intensely to ensure needed capabilities. And the Air Force is in the process of privatizing all its remaining six GOCO manufacturing facilities. Most Army vehicles, weapons, and equipment are manufactured in private facilities today. And most of the Army's ammunition procurement dollars already go to private rather than organic facilities. Privatizing part of the remaining organic base would simply represent a further shift toward what

is already the dominant manufacturing mode of defense production. The recapitalization option has the greatest potential to introduce new technology, although the other options do not preclude it.

With regard to the second criterion, financial, the principal measure of merit is long-term net present value. In other words, the long-term net benefit, taking into account the time value of money. While net present value is the accepted economic metric, in the Defense Department's programming and budgeting processes, payback period can be the determining factor, causing an option with a less impressive net present value but a fast payback period to be favored. At this point our assessment is based simply on a subjective assessment of potential costs and savings. Nevertheless, we suggest that the privatization option offers the best potential economic benefit because it is the one that most fully brings market forces and private-sector competitive incentives to bear. Creation of an FGC may prove a close second. Despite the constraints that a government charter may impose on an FGC, it would enjoy many of the economic advantages of a completely private firm including the economic incentives to use its assets to make and sell commercial items to the private sector.

The third criterion, managerial ease, takes into account an option's potential to enhance the ease of management of a workforce, improve processes, bring entrepreneurial incentives to bear, and provide access to capital. Privatization appears to offer the greatest potential, and the FGC option may be nearly as good. Both the Army-owned options for change appear inferior, although recapitalization would introduce new processes.

The three statutes cited in the fourth criterion either dictate reliance on the private sector or the use of economic efficiency as a criterion for placing work. Similarly the two citations under the fifth criterion, regulatory consistency, also encourage private-sector reliance.

Only the privatization option moves toward increased private-sector reliance.

Finally, external issues encapsulate the set of political issues surrounding the options. Obviously, it is politically easiest to maintain the status quo. Privatization may be the most difficult option around which to achieve political agreement because so many diverse political interests would be affected. But privatization of GOCO facilities could result in increased civilian employment with the loss of no more than a handful of government jobs. And, both privatization and consolidation would be difficult at the GOGO facilities because of the strong political power of the government workforces. Recapitalization is shown as the most difficult because it

implies uprooting all the existing enterprises and replanting them in a smaller number of new political jurisdictions, resulting in a loss to every jurisdiction in which a facility is now located.

It is not necessary to settle on a single approach, and strategies that mix elements of the four approaches are possible. Indeed, a set of mixed strategies is likely to offer the best approach.

The next phase of this research will include quantitative analysis of each option compared to the status quo.

CONCLUSIONS

All four broad options for change are considered feasible. Each offers distinct advantages over the status quo. None of the options necessarily threatens the ability to meet both programmed and replenishment requirements. Excess capacity can be divested in all options, but divestiture of excess equipment and buildings saves little. The cost of continuing to own excess equipment that is already paid for is low. The most significant avoidable costs are those associated with owning entire installations and employing personnel no longer needed.

Mixed strategies are likely to turn out to be favored over any pure strategy, because of the unique properties of the various installations and the unique activities they house.

One or more rounds of future BRAC, if they occur, will offer perhaps unique opportunities to achieve otherwise difficult changes. Further, such BRACs provide means of funding these changes.

Regardless of how the Army pursues the next phase of this research, it is imperative that the research be done as privately as possible to avoid unnecessary angst among the organizations and installations potentially affected.

ACKNOWLEDGMENTS

The authors benefited from the openness, hospitality, and estimable professional expertise of literally dozens of dedicated employees at the 16 ammunition plants and arsenals we visited. Further, we received excellent support and advice from key officials at the headquarters of the Operations Support Command (OSC), Rock Island, and at the headquarters of the Army Materiel Command (AMC). At the Pentagon, we are grateful to the members of our study advisory group, who guided our efforts throughout this phase.

While there are too many persons to thank individually, it is appropriate to mention several who, because of the sheer amount of time they spent as well as the value of their assistance, deserve special credit. At OSC, MG Joe Arbuckle, Al Wilson, Fritz Larsen, Tony Sconyers, and Al Beuster went well beyond the call of duty in teaching us, collecting data, setting itineraries, and otherwise just being helpful. Dozens of others at "the Rock" also turned to for us; we are grateful.

We appreciate the confidence our initial sponsor, MG Joseph M. Cosumano, Jr., displayed in our efforts. His support as well as that of his very capable team, particularly COL John Storm, LTC Lynda Lamitie, Tom Lanyi, Joseph Jenkins, and MAJ Jim Randazzo, made our tasks easier and, often, even enjoyable.

Participants in the study advisory group and the colonel-level steering committee meetings who have been especially valuable and generous with their time include Bob Raynsford and Sharon Weinhold of OASA (FM), Joe Pieper and Steve Linke of OASA (ALT), COL J. C. King of ODCS (LOG), and Jim Ball of AMC. We are particularly in the debt of LTC Jerry Glasow of ODUSA (OR), who served as everyone's intellectual conscience, posing the difficult questions at just the right time—always in a constructive manner.

The insightful comments of Vincent M. Russo (LTG, U.S. Army, Retired) and RAND colleague Kathi Webb substantially improved an earlier version of this report.

Finally, we wish to thank Shirley Lithgow, who, in enduring good humor, faithfully prepared the manuscript.

ABBREVIATIONS

AAP	Army Ammunition Plant
AMC	Army Materiel Command
ARDEC	Army Research, Development, and Engineering Center
ARMS	Armament Retooling and Manufacturing Support (Act)
ATACMS	Army Tactical Missile Systems
BAE	British Aerospace
BES	Budget Estimates Submission
BLM	Bureau of Land Management
BRAC	Base Realignment and Closure Commission
CAA	Center for Army Analysis
CBD	Commerce Business Daily
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CIL	Critical Items List
DCS	Deputy Chief of Staff
FASCAM	Family of Scatterable Munitions
FCS	Future Combat System
FGC	Federal Government Corporation
GDLS	General Dynamics Land Systems
GOCO	Government-owned, contractor-operated
GOGO	Government-owned, government-operated
GSA	General Services Administration
HE	High-explosive
HMMWV	High-mobility multipurpose wheeled vehicle
IAV	Interim Armored Vehicle

ICM	Improved Conventional Munition
JSOW	Joint Standoff Weapon
LAP	Load, assemble, and pack
MGS	Mobile Gun System
MIIF	Maintenance of Inactive Industrial Facility
MTW	Major theater war
OASA	Office of the Assistant Secretary of the Army
ODCS	Office of the Deputy Chief of Staff
ODUSA	Office of the Deputy Under Secretary of the Army
OIPT	Overarching Integrated Product Team
OMB	Office of Management and Budget
OSC	Operations Support Command
OSD	Office of the Secretary of Defense
OUSD	Office of the Under Secretary of Defense
PBP	Production Base Plan
PM	Program manager
POM	Program Objective Memorandum
RFI	Request for information
RFP	Request for proposal
RIA	Rock Island Arsenal
SAG	Study advisory group
TAA	Total Army Analysis
TACOM	Tank-Automotive and Armaments Command
TBD	To be determined
USOC	U.S. Ordnance Corporation
WVA	Watervliet Arsenal

1. INTRODUCTION

Phase 2: Assessment of Options

**Mike Hix
Dave Oaks
Bruce Held
Ed Keating
Michael Hynes
John Bondanella**

Arroyo Center

RAND

In the spring of 2000, the Office of the Deputy Chief of Staff for Operations and Plans, U.S. Army, asked the RAND Arroyo Center to undertake a DoD-directed study on the right sizing of the Army's arsenals and ammunition plants. By agreement with the sponsor, a Phase 1 report, limited in scope to manufacturing conducted at Rock Island and Watervliet Arsenals, was delivered to the Army in July 2000 but was not intended for publication.

This briefing, which reports on our Phase 2 research, deals with all 16 of the Army's arsenals and ammunition plants.¹ On November 15, 2000, we presented an abbreviated version of this briefing to the Study Advisory

¹The study encompasses five government-owned and -operated installations (Watervliet Arsenal, N.Y.; Rock Island Arsenal, Ill.; Pine Bluff Arsenal, Ark.; Crane Army Ammunition Activity, Ind.; and McAlester Army Ammunition Plant [AAP], Ark.) and eleven government-owned and contractor-operated plants (Holston AAP, Tenn.; Iowa AAP, Iowa; Kansas AAP, Kan.; Lake City AAP, Mo.; Lone Star AAP, Tex.; Louisiana AAP, La.; Milan AAP, Tenn.; Mississippi AAP, Miss.; Radford AAP, Va.; Riverbank AAP, Calif.; and Scranton AAP, Pa.).

Group (SAG).² By direction of the SAG, this second interim report is limited in scope to describing and assessing a broad range of options for governance and geographic dispersion of the activities. The SAG explicitly directed that we defer until Phase 3: (1) recommendations on the four options and (2) assessment of installation-specific options. Here we recommend a framework for analysis and offer a qualitative assessment of the four broad options.

²The SAG comprises representatives of OUSD (AT&L), OUSD (C), the Joint Staff, ODUSA (OR), OASA (ALT), OASA (FM), PAED, ODCSLOG, Center for Army Analysis (CAA), and Army Materiel Command (AMC) and is chaired by the director of Force Development, formerly in DCSOPS, recently transferred to the newly created DCS for Programs.

Where We Are

● Phase 1—Completed in July

- Principal insights
 - Excess space and equipment at Watervliet and Rock Island
 - Modest savings from divesting
 - Replenishment: requirements process slow, conservative, yields variable results, adequate capacity

Phase 2—August through November

- Assess options: governance and setting—16 ammo plants and arsenals
- Four options approved for assessment
- Principles and criteria
- Defer recommendations and installation-specific options

Phase 3—TBD

- Assess fabrication capacity at depots
- Develop installation-specific options and recommendations

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Our Phase 1 interim report conveyed three principal insights. First, that both arsenals were maintaining plant capacity and manufacturing equipment beyond their needs to meet either programmed or replenishment requirements. We endorsed an earlier AMC analysis revealing excess capacity at Watervliet and Rock Island arsenals. The report recommended that Watervliet divest of 43 percent of its equipment (reducing from 1,153 pieces to 653) and that Rock Island divest of 22 percent (reducing from 1,606 pieces to 1,249). Similarly, the report observed that the two arsenals could divest of 31 percent and 29 percent of their manufacturing space, respectively. That divestiture is under way. The report observed that a more thorough scrub would likely reveal that greater divestitures are possible, but unlikely to substantially improve efficiency.

The Phase 1 report also estimated that such divestitures would save little money, on the order of only \$5.2 million cumulatively, net of costs, between FY01 and FY07. The recurring annual savings represent less than one-half of one percent of the annual operating costs of the two arsenals.

Finally, the report demonstrated that the process by which replenishment requirements are developed is slow and conservative, yielding generous requirements that vary widely from year to year. However, capacity at the two arsenals was considered more than adequate to meet anticipated needs.

Later in this report, we address the difficult issue of future requirements and the need to hedge against uncertainty associated with them.

This briefing constitutes a draft report of our Phase 2 research. At the outset of Phase 2, the SAG directed us to develop and assess an array of broad options dealing both with forms of governance and organization as well as with geographic setting of the activities now located at the 16 installations. In August, the SAG approved the following four options for further assessment: privatization, creation of a Federal Government Corporation (FGC), consolidation within existing industrial facilities, and recapitalization and unification of the base on other, enduring multifunctional installations.

As we learned in Phase 1, to reduce unneeded capacities at an existing installation costs money to execute and saves little. Hence, we base this phase of our research on the proposition that more substantial improvements in operations and savings are possible through changes in governance, consolidation, or recapitalization of the activities of entire installations.

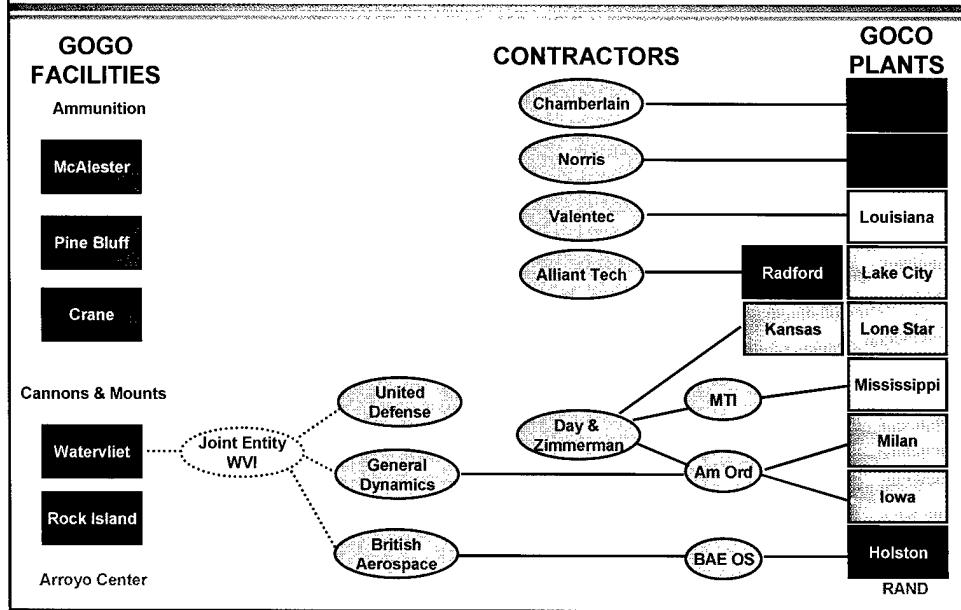
How many installations to own is a more important decision than how much equipment to maintain on an installation the Army owns. By privatizing a function, one eliminates the need for the Army to own any installation at all for that function. By creating an FGC, the requirement is similarly transferred out of the Army and DoD. By consolidating or recapitalizing, one reduces but does not eliminate, the need for installations.

As mentioned previously, the scope of Phase 2 was intentionally limited to the setting forth of principles and criteria and assessment of options at a general rather than installation-specific level. Further, this phase purposely omits any recommendations on the four options.

Phase 3 will consist of two tasks. The first will assess the fabrication capabilities and capacities at the Army's depots. We will examine the policies under which fabrication workload goes into the depot as well as the requirements to maintain the fabrication capabilities themselves.

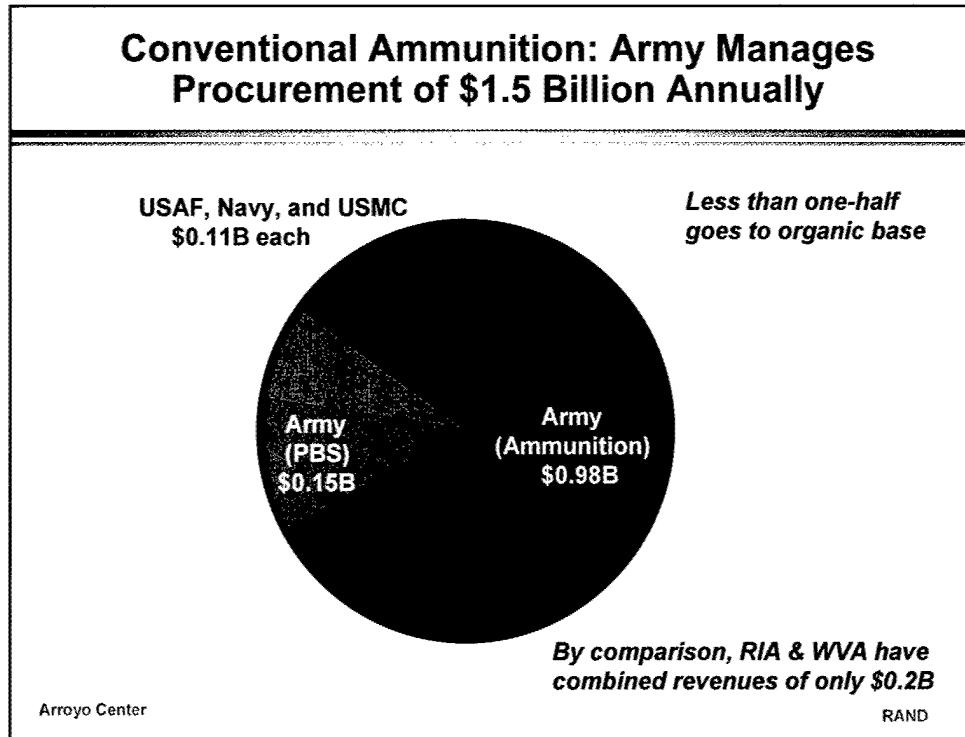
The more substantial second task entails deriving specific options within the four broad ones, then conducting detailed cost and feasibility analysis on these. The Army is in the process of deciding the relative roles of RAND and internal Army analytical agencies in the conduct of this task. Further, decisions as to the commencement and duration of this task are still to be made.

16 Government Installations Under Study in Phase 2



The 16 facilities under review in this phase fall into the following three categories: 2 government-owned and -operated (GOGO) "hard iron" arsenals that manufacture ordnance-related items; 3 GOGO ammunition plants (two of which serve principally as Tier 1 ammunition depots); and 11 government-owned, contractor-operated (GOCO) ammunition plants. Holston and Radford manufacture energetics; Lake City, Lone Star, Kansas, Milan, and Iowa load, assemble, and pack (LAP) ammunition; Scranton, Riverbank, Mississippi, and Louisiana make metal parts.

Each of the 11 GOCO plants is operated by one of seven firms, but significant interrelationships stem from recent mergers and acquisitions. For example, American Ordnance operates both Milan and Iowa and is half-owned by Day and Zimmerman, which also operates Kansas and Lone Star. Day and Zimmerman also owns MTI, which operates Mississippi. Alliant Techsystems operates both Radford and Lake City. BAE Systems Ordnance Systems runs Holston. General Dynamics, which owns the other half of American Ordnance, was one of three firms that last spring created a joint entity, Watervliet International, that made an ill-fated, unsolicited offer to operate Watervliet Arsenal as GOCO. General Dynamics now owns Primex as well. Without prospects for increased ammunition buys, consolidation is likely to continue.



The above figure and the two that follow illustrate the relative magnitude of the ammunition and ordnance materiel missions. The Army manages about \$1.5 billion of conventional ammunition procurement annually.³ About three-fourths of that is appropriated to the Army; the remaining quarter comprises about \$110 million appropriated to each of the other three services but managed by the Army as DoD's Single Manager for Conventional Ammunition.

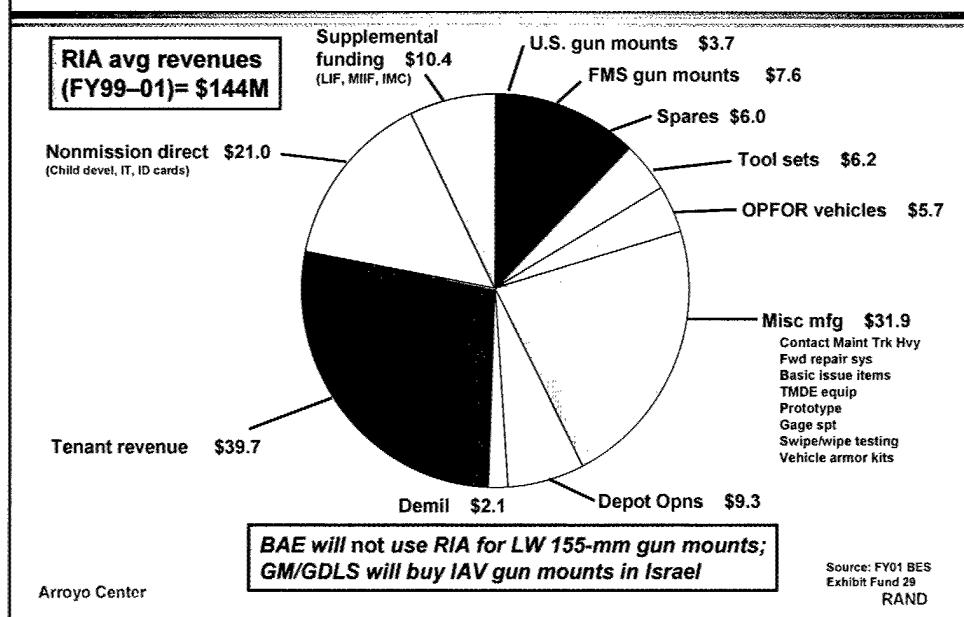
Of the Army appropriation, about \$150 million is earmarked for production base support, a category that includes ammunition demilitarization, funding for layaway and maintenance of inactive equipment, capital improvements, and funding authorized by the Armament Retooling and Manufacturing Support Act of 1992—a program of infrastructure investments intended to attract commercial tenants onto these installations.

³U.S. Department of the Army, *Committee Staff Procurement Backup Book: FY2001 Budget Estimate: Procurement of Ammunition*, Army, February 2000; U.S. Department of the Navy, *Fiscal Year 2001 Budget Estimates: Procurement of Ammunition Navy and Marine Corps, Budget Activities 1 and 2*, February 2000; U.S. Department of the Air Force, *Committee Staff Procurement Backup Book: FY 2001 Budget Estimates: Procurement of Ammunition*, February 2000.

While the exact proportion is difficult to ascertain from highly aggregated budget documents, most ammunition dollars flow into privately owned plants of some 69 commercial producers rather than into the 14 government-owned facilities. Hence, the Army relies on commercial producers that principally manufacture components in their own facilities for most of its ammunition production activity. Commercial manufacturers using the 11 GOCO ammunition plants do a minority of the manufacturing, yet receive the lion's share of Army management attention.

The combined budgets of Watervliet Arsenal (WVA) and Rock Island Arsenal (RIA), which produce such nonammunition items as cannon and gun mounts, are much smaller than the conventional ammunition operation, totaling only \$200 million, compared to the \$1.5 billion ammunition budget.

Gun Mounts Account for Less Than 10% of RIA Revenue



A traditional competency and mission of Rock Island, the manufacture of gun mounts and recoil mechanisms for howitzers and tanks, now constitutes less than 10 percent of the arsenal's total revenues of \$140 million.⁴ The arsenal engages in a wide array of related manufacturing activities that rely less on the highly specialized capabilities than do the traditional activities. These peripheral activities include the assembly of tool kits from commercially procured tools, the fabrication of aluminum turrets that give opposing forces vehicles at the National Training Center the appearance of foreign vehicles, the fabrication of mobile shops that fit into high-mobility, multipurpose, wheeled vehicles (HMMWVs), and a large array of other small manufacturing tasks. While these activities provide productive employment for the existing government workforce, they are not the kinds of activities for which one would create an arsenal. Additionally, Rock Island performs a depot function for Tank-Automotive and Armaments Command (TACOM) and demilitarizes small arms and other items. Rock Island's largest nonmanufacturing activity is that of landlord to 40 tenants whose rents bring in revenue of nearly \$40 million a year. Major tenants include the headquarters of the Operations Support

⁴Individual item revenues are three-year (FY99-01) averages taken from Exhibit Fund 29 of the FY01 working capital fund budget estimate submission, dated May 1999.

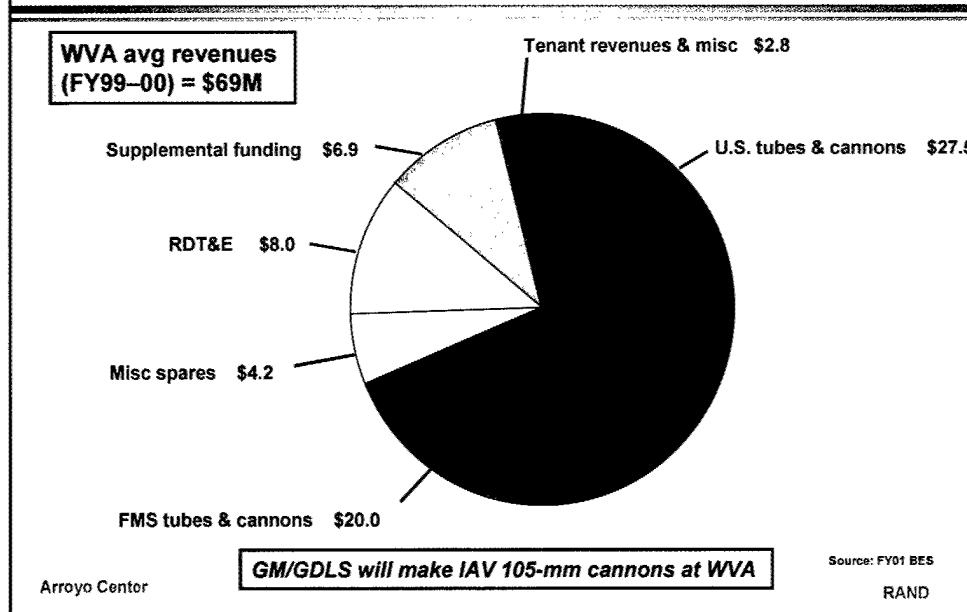
Command (OSC), TACOM, Defense Finance and Accounting Service, North Central Civilian Personnel Operations Center, Army Audit Agency, U.S. Army Industrial Engineering Activity, and Navy and Marine Corps Reserve Center.

Finally, RIA received about \$10 million a year in supplemental funding to lay away equipment, maintain that which has already been laid away, and to subsidize the arsenal for replenishment-required equipment used at less than 20 percent of its capacity. This supplemental funding varies from year to year (see footnote 7).

Of note is a decision by BAE, the systems contractor for the new lightweight 155mm howitzer, to make the howitzer's gun mounts at facilities other than Rock Island, probably offshore.⁵ Similarly, Rock Island lost the most recent opportunity to rebuild its gun mount business when General Motors/General Dynamics, the winning contractor for the Interim Armored Vehicle (IAV), decided to go offshore to Israel for gun mounts. These decisions substantially reduced the opportunity for Rock Island to raise its level of gun mount production.

⁵BAE has experienced delays and cost increases in developing the lightweight 155-mm howitzer, a substantial technological leap in howitzer design. Gun mounts have not been identified as part of the problem (U.S. GAO, 2001). Interviews with BAE officials suggest that most of the technological problems have been solved.

WVA Has Half the Revenues of RIA and Is Better Concentrated on Its Principal Products—Cannons and Tubes

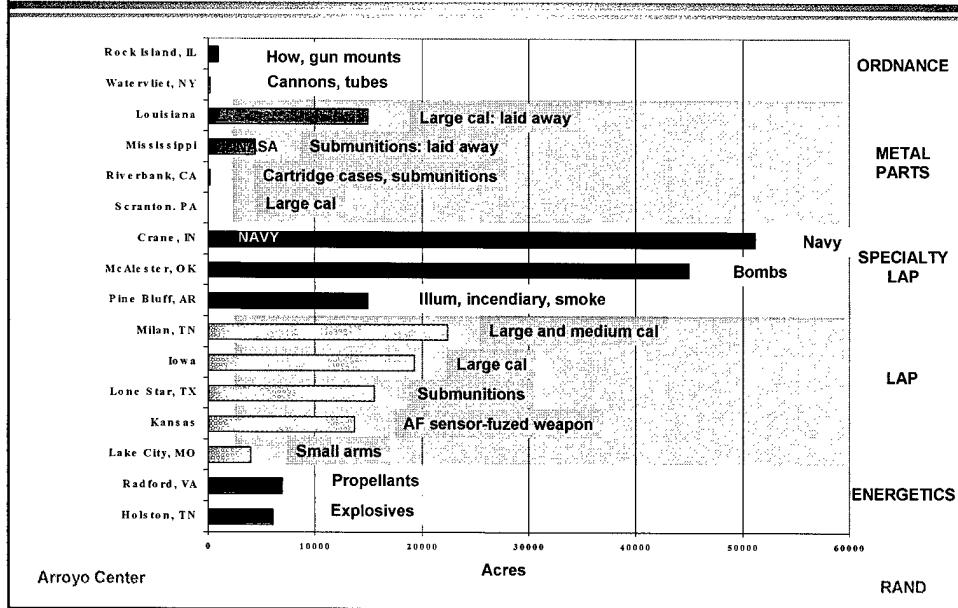


WVA differs from RIA in both its level of revenue and the extent to which it is concentrated on its principal mission. First, WVA's revenues are about half of those of RIA. But WVA production is better concentrated on its principal products: cannon and gun tubes.⁶ Fully two-thirds of WVA's revenue results from cannon and tube production, most of which is for U.S. rather than foreign military sales. About 12 percent of WVA's revenues come from research, development, test, and evaluation work the arsenal performs principally for its partner and principal tenant, Benet Laboratories of the Armament Research, Development and Engineering Center. Like RIA, WVA receives a significant amount of supplemental funding each year. A budgeted increase of \$20.1 million in FY01 funding for one category of supplemental funding—industrial mobilization capacity—was in part the reason the Office of the Secretary of Defense directed the Army to conduct this study.⁷

⁶A cannon includes a tube, breech, and either bore evacuator (for a tank cannon) or muzzle brake (for a howitzer).

⁷While the \$20.1 million was included in the industrial mobilization capacity line of WVA's working capital fund budget, the funds actually represented an estimate of the amount required to maintain the arsenal's direct labor rate at a stable level in the face of an unexpected decline in FY01 workload rather than the amount needed to maintain unutilized capacity.

The 16 Installations Manufacture Five Classes of Products



This figure arrays the 16 installations by acreage within five classes of production: (1) ordnance items, such as gun tubes and gun mounts manufactured at the GOGO facilities of Watervliet and Rock Island; (2) metal parts, manufactured at GOCO facilities at Louisiana, Mississippi, Riverbank, and Scranton; (3) LAP operations of a special nature conducted at the GOGO facilities of Crane, McAlester, and Pine Bluff; (4) other GOCO LAP at Milan, Iowa, Lone Star, Kansas, and Lake City; and (5) energetics at the GOCO facilities at Radford and Holston. The GOGO LAP operations at Crane, McAlester, and Pine Bluff, though specialized, are compatible with LAP done at other plants.

The 16 installations under study range in size from Crane Army Ammunition Activity, housed on a Navy-owned installation of more than 50,000 acres southwest of Bloomington, Ind., to Scranton AAP on 15 acres of land in the heart of Scranton, Pa. The two largest facilities, Crane and McAlester, serve principally as Tier 1 ammunition depots; ammunition production represents about one-third of their combined revenues.

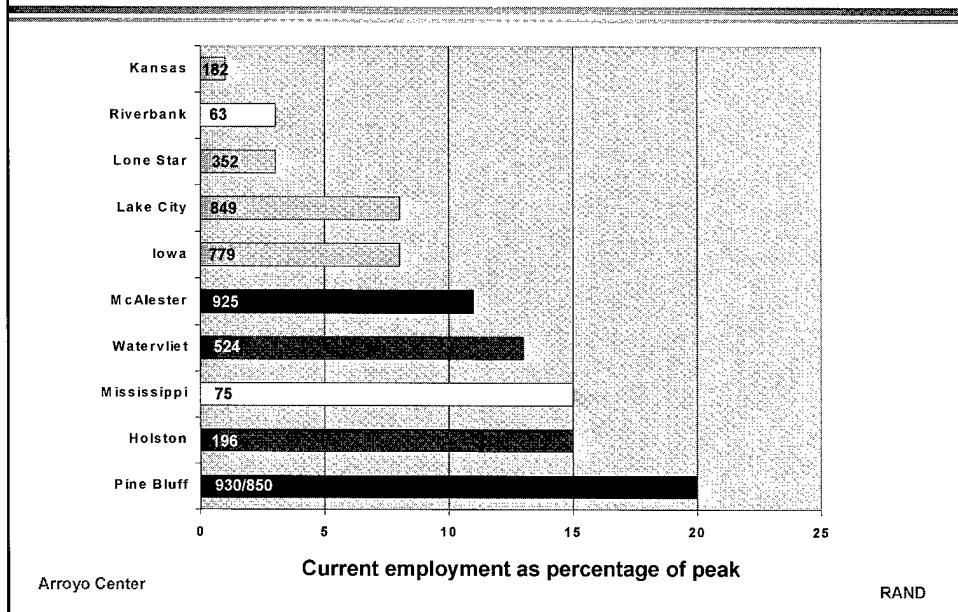
Crane and McAlester, both GOGO operations, operate under protective legislation that precludes the Army from contracting out any functions performed by DoD personnel at the two sites when the legislation was

enacted in 1986.⁸ This legislation ensures that both the base support and historical manufacturing operations at these two plants will remain GOGO. This legislation as well as the importance of these installations as depots make them candidates to receive functions considered for realignment away from other facilities.

Six other installations—Milan, Iowa, Lone Star, Louisiana, Pine Bluff, and Kansas—exceed 10,000 acres. Low rates of production at these plants relative to historical peaks indicate excess capacity that, in the event the Army decides to consolidate, would add them to the list of logical candidates to receive functions realigned away from other installations.

⁸Section 317, Public Law 99-661, November 14, 1986.

Plants Now Employ Only a Fraction of Their Peak Workforces



This figure illustrates the relatively low levels of activity at 10 installations for which historical data are available. The lengths of the bars indicate current employment as a percentage of historical peak employment. None of the installations shown is operating at employment levels greater than 20 percent of peak. The time of the peaks varies from installation to installation—some occurred during World War II, others during the Korean War or Vietnam era. Certainly, increased productivity has reduced the need for some of the workforce, but the predominant factor is a decline in workload. At any rate, the current low levels provide some rough indication of the excess land and facilities now available at these plants. They also indicate the availability of a hedge against future increases in requirements.

Army Industrial Base Initiatives

- GOGO
 - Joint Entity (UDLP, GD, BAE) proposed to convert WVA to GOCO
 - Sole-source J&A rejected by DA
 - No governance initiatives on other GOGOs, except for A-76 for some support services at RIA
- GOCO ammunition plants
 - Plants rendered excess still on books: slow process
 - Long-term (5- to 10-year) firm fixed-price ammo supply contracts
 - Longer-term (25-year) facilities-use contracts and ARMS investments to attract tenants
 - Spent \$200 million on ARMS since 1993; continuing to spend \$20 million a year; annual tenant revenue now \$32 million—in-kind services
 - Use some ARMS revenue for environmental remediation; divest later
 - Competing LAP plants under consideration

Arroyo Center

Contracts and tenant leases encumber installations

RAND

Among the GOGO facilities, the most significant recent initiative related to governance was an unsolicited proposal from a joint entity formed from British Aerospace, United Defense, and General Dynamics Armament Systems to operate Watervliet Arsenal as a GOCO facility. Through a complex set of actions within the Army, the proposal died. An A-76 action for base support services at Watervliet produced no commercial bidders. Now under way is an A-76 action for logistics services and information technology at Rock Island. Also, Rock Island has developed a master lease plan to encourage increased tenancy. It is not entirely clear how Rock Island's master lease program will mesh with the new Arsenal Support Program Initiative authorized by Section 343 of the FY01 National Defense Authorization Act. Both Watervliet and Rock Island are designing demonstration programs for FY01 and FY02, intended to bring tenants onto the installations. Apart from these initiatives, there are no active plans for changing the governance or operating paradigms of the GOGO facilities.

Among the GOCO plants, 11 excess ammunition plants—10 declared excess outside of BRAC and one closed as a part of BRAC—remain on the Army's books. The disposal process is slow, as a later figure depicts.

AMC is in the process of executing long-term (5- to 10-year), firm fixed-price supply contracts with ammunition producers. The firm fixed-price

feature of the policy is intended to reduce costs by providing incentives for producers to become more efficient. The long terms of the contracts make it more attractive for firms to invest in productivity-enhancing capital.⁹ At the same time, the Army has begun entering into longer-term (25-year) facilities-use contracts with GOCO facilities-use contractors, who also are the ammunition suppliers. This stability permits the contractors to attract commercial tenants to their installations. Tenant revenues can offset the costs of ownership of a plant. The Armament Retooling and Manufacturing Support Act of 1992 (commonly referred to as the ARMS Act and recently codified as 10 USC Chapter 434) supports this concept by authorizing a program under which funds are appropriated to permit infrastructure investments to attract commercial tenants. Section 343 of the National Defense Authorization Act for 2001, mentioned above, has authorized a demonstration project of a related nature for the Army's arsenals.

In some cases, the Army hopes to induce facilities-use contractors to finance environmental remediation with tenant revenues so that the Army can later declare installations excess and offer relatively clean property for disposal.

This is not necessarily a bad strategy, except that it is not clear that all the currently producing ammunition plants are needed today. Consequently, for unneeded plants, commercial revenues are being applied to reduce infrastructure costs that could otherwise be eliminated by shutting down and then divesting of the plant. Should the Army elect to consolidate its ammunition production, needed capabilities and capacities can be consolidated onto a smaller number of installations, rendering some facilities excess. One should not confuse the need for a production line that today happens to be situated on an installation with the need for the installation itself. Lines can be moved and, in the process, installations rendered excess. Hence, it seems appropriate first to decide the optimal assignment of capabilities and capacities to installations before investing further in ARMS improvements and encumbering installations with long-term contracts and tenants. Appendix A provides our assessment of the Army's experience with the ARMS program.

⁹The conversion to firm fixed-price contracts has also shifted responsibilities from the government to contractors, reducing the requirements for government management. Under the old cost-plus contracts, government employees were required to monitor cost and overhead structures of contractors, as well as schedule and quality compliance. Under the firm fixed-price contracts, overhead costs are implicit in the final contract cost. Once prices are agreed to, the contractor's actual costs are not of day-to-day concern to plant commanders and other government managers but are of concern to the contractor.

Nine of 11 GOCO Installations Are Nearing Window for Renewal of Facilities-Use Contracts

CONTRACTOR	PLANT	FACILITY USE CONTRACT	Expires	Planned
Chamberlain	Scranton		01	10-year
Norris	Riverbank		05	5-year
Valentec	Louisiana		02	5-year
Alliant Tech	Radford	02/25	23-year/?	
	Kansas	01/03	?/25-year	
	MTI	00	?	
General Dynamics	Day & Zimmerman	03	25-year	
British Aerospace	Am Ord	03	25-year	
Arroyo Center	BAE OS	23	?	
	Holston			RAND

In the last two years, the Army has executed two 25-year facilities-use contracts with ammunition manufacturers, first with BAE Systems Ordnance Systems at Holston and most recently with Alliant Techsystems at Lake City. Existing contracts at eight of the other nine expire within the next three years. The contract at Mississippi expired in FY00 and is continued on a month-to-month basis for the time being. The Army plans to offer 23- to 25-year contracts at most of these.¹⁰ The existence of these long-term contracts will at best make it costly to implement the options in this report. At worst, they will prevent the options from being executed at all.

¹⁰The Army plans to execute a 23-year contract at Holston so its expiration will coincide with that of the other energetics plant, Radford, in FY25.

Excess Plants Still on Books; Take an Average of 12 Years to Dispose of Last Acreage

	FISCAL YEAR OF		
	DISPOSAL APPROVAL	LAST ACRE DISPOSED	YEARS TO DISPOSE
<u>NON-BRAC</u>			
Cornhusker	94	05	11
Joliet	96	10	14
Indiana	98	13	15
Kansas	98	15	17
Longhorn	98	07	9
Sunflower	98	14	16
Volunteer	99	08	9
Badger	00	05	5
<u>BRAC</u>			
Alabama	88	03	15

Two plants, Twin Cities and Ravenna, are to remain in inventory for NG use

Arroyo Center

RAND

Ten plants declared excess in the last six years are still on the Army's books. While parcels of these plants have already been removed from the Army's accounts, none is expected to be completely disposed of before 2005. On average, these facilities will take 12 years to entirely dispose of. Two plants, Twin Cities and Ravenna, will remain on the rolls for training use by the National Guard. In addition to the 10, the Alabama plant, closed under the 1988 BRAC round, is expected to remain on the Army's books until 2003.

Excess Property May Be Transferred More Expeditiously—Army Action Needed

- Environmental remediation is responsible for much of delay in transfer
- 42 USC 9620 authorizes transfer of property before remediation is complete
 - If property is deemed suitable for intended use
 - Transfer action does not delay remediation
- In February 2000 OSD/Army team designed process for accelerated transfer
 - Intent: reduce disposal time from more than 10 years to three
- Accelerated disposal plan not yet implemented

Arroyo Center

RAND

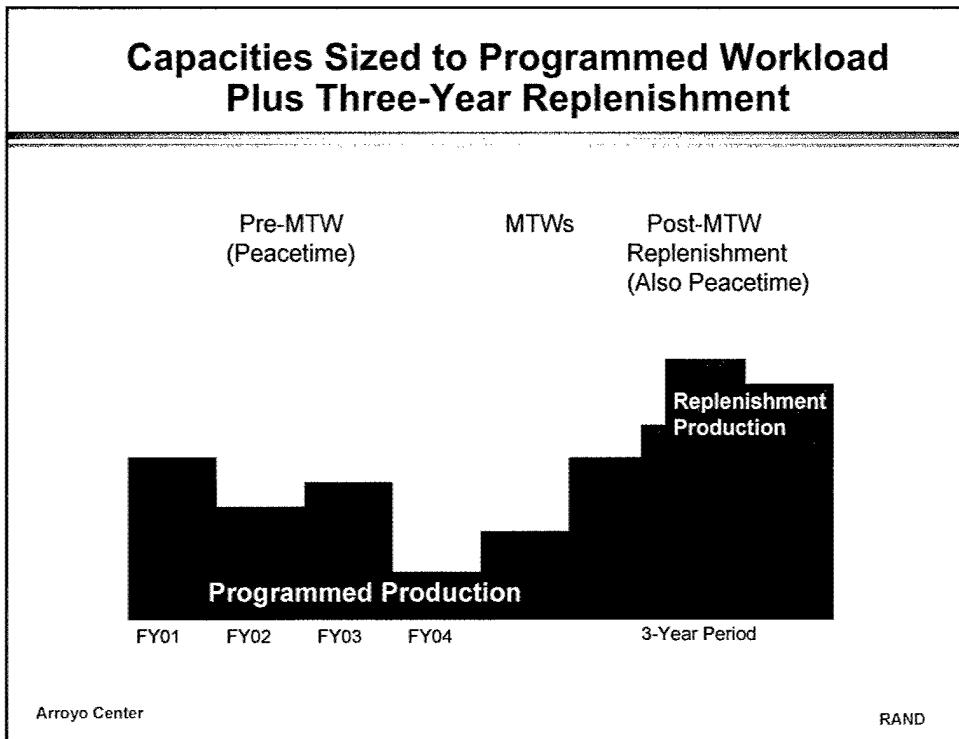
Much of the delay in transferring excess property is due to the Army inadequately characterizing environmental conditions. Before the General Services Administration (GSA) begins its process of disposal, it requires environmental characterization according to standards set forth by the American Society for Testing and Materials, but the Army follows instead the guidelines set forth in Army Regulation 200-1, which GSA finds insufficient. Further, the Army's policy, described above, is to conduct all environmental remediation before beginning the disposal process.

42 USC 9620 contains a provision, enacted in 1997, permitting property to be transferred before environmental remediation is completed, provided the property is deemed suitable for the intended use and the transfer does not delay the remediation. When it uses this early transfer authority, the Army retains the liability for the cleanup and may either continue to fund the cleanup at its programmed rate or negotiate the payment of the cleanup with the transferee who receives the property. This authority is being used somewhat unsatisfactorily in the disposal of Sunflower AAP. It is not clear, however, whether the mixed outcome of this endeavor indicates a shortcoming of the legislative authority or was due to factors specific to Sunflower. Such an assessment lays outside the scope of this research.

In February 2000, a team composed of staff members of the Office of the Secretary of Defense, the three Military Departments, and GSA convened to design a rapid transfer process using the early transfer authority provisions of 42 USC 9620. The recommendations laid out in the report¹¹ of this activity have yet to be implemented. Discussions with staff officers in the Army Secretariat and the Army staff indicate an acceptance of the idea of using this authority but reluctance to accept the specific procedural recommendations of the rapid improvement team.

¹¹U.S. Department of Defense, *Developing an Accelerated Industrial Base Property Disposal Process*, Rapid Improvement Team, February 1999. While the draft report carries a February 1999 date, members of the team report that this is an error; the proper date is February 2000.

2. REQUIREMENTS



In this chapter, we describe current policies that generate the requirements to manufacture ordnance materiel, discuss how those requirements might change in the future, and analyze the role of current and future requirements in assessing the four options presented later in this report. Two related appendixes lay out the specifics of current requirements and capabilities and assess the process by which replenishment requirements are generated.

CURRENT POLICY

Under current policies, ordnance materiel is needed for two purposes. First, some materiel is required to satisfy programmed buys—materiel programmed for training and for possible use in the two MTWs that represent our current national military strategy. As the figure shows illustratively, this production varies from year to year. Current policy assumes the two MTWs are fought and won without relying on expansion of the industrial base; no surge is assumed. Second, materiel is needed to replenish stocks consumed during the two MTWs. The second is a

contingent requirement in that replenishment-required materiel is to be procured only if the two MTWs are consummated.

Current policy requires capacity to be maintained to manufacture one MTW's worth of replenishment materiel generally within three years after the completion of the two MTWs.¹² Conceptually, such capacity may be maintained either in government-owned facilities (either GOGO or GOCO) or in nongovernment facilities, although policy and statute as well as economic theory require the department to rely on the private sector to the maximum extent possible. The Army assumes in its planning that currently programmed levels of production will continue, making replenishment production additive. We challenge these and other assumptions in Appendix C.

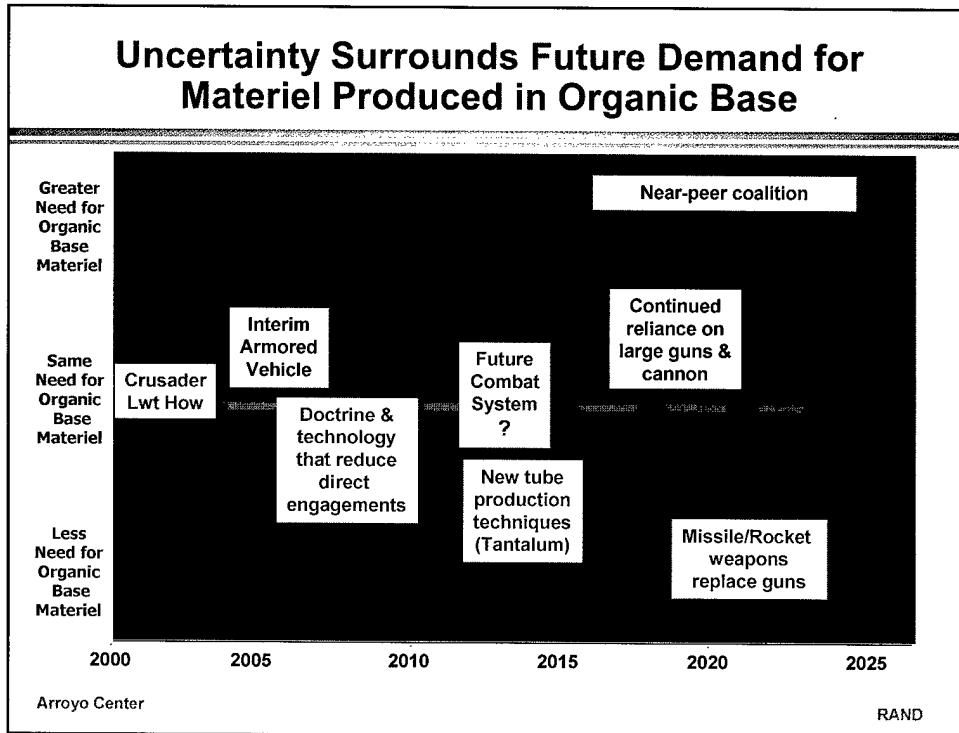
Capacity required during replenishment but not needed to meet programmed requirements may be laid away either in private or government-owned facilities. As we demonstrated in our Phase 1 report, most arsenal equipment required for replenishment is active today but at a fraction of its capacity rate. Highly capable equipment designed to produce cannon at high Cold War rates is used only at a fraction of even its single-shift capacity. In Phase 2, we discovered that such is also the case with equipment at the ammunition plants. The plants house 73 required ammunition lines,¹³ most of which are active today, as follows:

Active today	
DoD production	49
Demil/small jobs	3
Commercial work	5
Active in later Program Objective Memorandum (POM) years	
	6
Active only for replenishment	
	7
For technology	
	3
TOTAL	
	73

¹²In April 2000, policy is silent on ammunition replenishment. It does, however, continue to specify three years as the replenishment period for other ordnance items, such as gun tubes and gun mounts.

¹³The Army has shrunk its organic ammunition capacity substantially since 1991, when it had 270 lines. To date, 197 of those lines have been declared excess. Of that number, 86 have been disposed and 111 are awaiting disposal. These actions have also rendered many buildings excess, offering opportunities for consolidation. Source: OSC staff.

Fifty-seven of the 73 are producing ammunition today and six others are expected to begin doing so sometime during the next six POM years as the mix of required munitions changes. Only seven lines are laid away for replenishment. Virtually all producing lines operate today on a one-shift basis.



CONSIDERING THE FUTURE

Because decisions affecting either organic or commercial capabilities and capacities¹⁴ can be expensive and time-consuming—or even impossible—to reverse, those making such decisions should approach them with caution. Prudence dictates that the United States be able to meet not only today's requirements but future ones as well. And it cannot be known with certainty what those future requirements may be. Hence, it is appropriate to maintain a hedge against plausible future demands. The Army can maintain such a hedge through a combination of organic and private-sector capabilities and capacities.

Regardless of where the hedge is maintained, decisions as to its extent should consider several questions whose answers are not knowable today. The appropriate hedge depends in part on how the Army will be equipped in the future and how that equipment will be armed. For example, the Army now plans to develop a future combat system (FCS) whose armament has not been decided. If the FCS turns out to employ missiles rather than

¹⁴The term "capability" is defined as the ability of a facility to manufacture a certain item. The term "capacity" has to do with the rate at which a facility can produce that item.

traditional guns, arsenals will not be needed to arm the vehicle and the current capabilities of the GOCO ammunition plants may not be useful in producing the missiles.¹⁵ For many years, all the military departments have relied almost entirely on the private sector for missiles.

In a recent visit to WVA, we were briefed on the development of a new tantalum coating for the interior of gun tubes. The new coating is expected to triple tube life and concomitantly reduce production requirements. Even in the absence of changes in threat or resulting national security strategy, evolution in technology and how the Army employs it will influence the appropriate future size and composition of the industrial base.

But, broader questions also bear on the future need for arsenals and ammunition plants. A new national security strategy, based on preparedness to fight a near-peer coalition¹⁶ rather than two regional powers, could imply an increase in force structure and a concomitant increased demand for arsenal-related items. Among the various future possibilities, the emergence of a near-peer threat or radical technological developments carry the greatest implications for the organic base.

The manifestation of a near-peer threat would likely emerge over time rather than appear suddenly. And as a new threat emerges, the United States will necessarily first respond in ways far more significant, costly, and time-consuming than the concurrent or perhaps even subsequent revision of its arsenals and ammunition plants and their private complements. With a new threat, one could reasonably expect a new national security strategy to direct increases in force structure, changes in the composition of that structure, and changes in equipment and its armament—acts likely to take years to accomplish. These acts, which cannot be predicted today and which, therefore, cannot be easily hedged against, will dictate much of the nature and extent of changes in the industrial base, including the arsenals and ammunition plants.

¹⁵The Army is studying a multirole cannon for the FCS that would have both a line-of-sight and non-line-of-sight (indirect) capability, but other options are likely to be considered before a decision is made. See *Inside the Army*, Vol. 12, No. 28, July 17, 2000, p. 1.

¹⁶We use the term near-peer “coalition” instead of the more common near-peer “competitor” to emphasize that national powers that individually might not pose a threat of a near-peer magnitude can rapidly and perhaps unexpectedly form a coalition with sufficient collective strength to be considered near-peer in stature.

CURRENT REQUIREMENTS AND CAPACITIES TO MEET THEM

It would seem inappropriate to assess the four broad options outside the context of anticipated production requirements and existing capacities. Yet, as we argue below, requirements and capacities play only a small role in assessing the broad options laid out in this phase of the research. Such is the case because none of the options necessarily affects capabilities or capacities.

For that reason, we provide in Appendix B rather than in the text a characterization of the relationships among programmed requirements, replenishment requirements and current capacities (organic, private U.S., and foreign).

While programmed requirements vary from POM to POM, for any given one they are unambiguous. Such is not the case with replenishment requirements. As we demonstrate in Appendix C, replenishment requirements are derived from a process that employs generous and challengeable assumptions and takes more than two years to complete, ensuring that, at any given time, production base plans are always two years or more out of date.¹⁷ Hence, replenishment requirements should not be taken at face value.

The broad options we develop and assess in this phase are consistent with a wide range of programmed requirements, replenishment requirements, and existing capacities. Within a reasonable range, the magnitude of requirements and capacities are largely irrelevant in assessing the broad options under review in this phase of the research. They will later become relevant, however, as specific options are costed out in Phase 3. For example, the positive and negative considerations surrounding a broad decision to privatize are largely independent of the size of the programmed and replenishment requirements and the existing capacity, or of the relative magnitudes among the three. But in later costing out a specific privatization option, the size of these requirements may affect the amount of equipment privatized and its market value. A potential buyer who anticipates small production orders relative to the capacity of the equipment needed is likely to offer the Army less for the needed equipment than would be the case if relatively large production orders are expected. Hence, specific requirements and capacities will play a larger role in the

¹⁷Most of the two-year elapsed time is required by the AMC in its development of a production-base plan. The Department of the Army staff also uses considerable time in developing a critical items list.

next phase of the research, but the assessment need not await a revision of the process.

Similarly, the advantages and disadvantages of privatizing are largely, but not completely, independent of the size of the external market. Privatizing into a robust market could yield large economic benefits. On the other hand, privatizing a sole source could result in replacing a government monopoly with a private one. All other factors being equal, it is not clear whether such a substitution would result in net economic benefits or costs. Nevertheless, such a substitution could be expected to yield management benefits by permitting the Army to better focus its management attention on essential functions. But the likelihood of this hypothetical monopolistic situation appearing seems remote.

Because the information may have limited relevance to the Phase 2 assessment at hand and will be needed as a foundation for Phase 3 research, we present in Appendix B our assessment of current programmed and replenishment requirements as well as current capacities, both government-owned and external. And, in Appendix C we offer a critical assessment of the process by which the replenishment requirements are developed. This information is relegated to appendixes, however, to give prominence in the main body to the assessment of options.

3. ASSESSMENT OF OPTIONS

The Four Visions Incorporate Both Governance and Setting	
Privatize: To Divest of Peripheral Functions, To Harness Private Incentives	<ul style="list-style-type: none">– Maximum privatization– Any remaining Army-owned assets on substantially smaller number of single-purpose installations
Create an FGC: To Divest of Peripheral Functions, To Retain Gov't Control	<ul style="list-style-type: none">– All Army assets transferred to an FGC with bottom-line incentives and entrepreneurial freedom– Either corporation or Army can decide on disposition of assets
Consolidate: To Achieve a More Efficient Base	<ul style="list-style-type: none">– Current mix of GOGO, GOCO, and commercial producers– Army-owned assets consolidate on smaller number of single-purpose installations
Recapitalize and Unify: To Meet New Demands, To Achieve Efficiencies	<ul style="list-style-type: none">– Regardless of extent of privatization– Recapitalize remaining Army-owned assets at large, enduring, multipurpose DoD installations

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The SAG approved four core ideas to serve as the basis for later developing specific options for change. These core ideas involve governance (i.e., who should own and operate the activities) and setting (i.e., where they should be).

The first of these, privatizing, takes as its objective the maximum extent of privatization of existing activities. By privatizing, we mean divesting of the means of production and simply buying the products from private firms. The option permits consolidation of any assets considered inappropriate for privatization onto a smaller number of installations, but the imperative underpinning this option is to privatize.

The second idea, creating an FGC, would transfer all the production assets to a congressionally chartered FGC. (More detail on the characteristics of FGCs follows in the section devoted to this option.) Implementation options would permit either the Army before transfer or the FGC after transfer to consolidate and divest of unneeded assets. Because of its entrepreneurial freedom and bottom-line incentives, the FGC could be

expected to find broader uses for the plants, equipment, and land than does the Army today. Hence, the two organizations might arrive at different conclusions as to which assets are needed.

The third idea, consolidating, takes as its guiding principle the imperative to consolidate functions on as few of the existing properties as possible to divest of unneeded land, buildings, and equipment, thereby saving base support costs, and to achieve economies of scale in manufacturing by collocating manufacturing operations. The remaining set of manufacturing activities continues to be accomplished on a subset of the existing single-function ammunition installations.

Finally, recapitalizing and unifying the base is driven by two assumptions, namely that, in the long run, new manufacturing technologies will be required and the Army will want to get out of small, single-function installations and consolidate onto more enduring, multifunctional installations, perhaps multiservice ones. Recapitalization means that manufacturing moves from today's single-function ammunition installations to installations that serve other purposes as well.

The subsequent figures in this section describe and assess these four pure options. A subsequent section compares the four against a set of criteria and explores the notion of mixed strategies.

About the Options

- All options still considered feasible
- None necessarily affects capacity, only who owns it and where it is.
Hence:
 - Assessment is largely independent of replenishment issues
 - Current capacity carries low risk for ordnance items, modest risk for ammunition
 - External market relevant in deciding equipment and installation disposition, not viability of option
- All options bear significant political implications
 - BRAC may be essential to privatizing, consolidating
 - Further analysis and strategy-making needs to be a private process

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While a detailed analysis of the four options is to occur in Phase 3, at this point in the study we can report that all four options appear feasible and worthy of further consideration.

Early in the study we spent a great deal of time developing an understanding of both programmed and replenishment production requirements. It is important that all options take into account any increased risk associated with reduced capabilities or capacities. All four options permit the retention of needed assets. None arbitrarily reduces the ability to produce required items. As shown above, current capacities carry low risk for meeting replenishment requirements for gun tubes, cannon, and related items and modest risk for ammunition.

Similarly, we have spent a great deal of time, as detailed in Appendix B, assessing the domestic and worldwide markets for the items produced in the base at hand. The four options have the benefit of ensuring that all needed physical assets can remain in play in the market. Smart contracting and judicious acquisition strategies can ensure the continued existence of essential privatized assets. Hence, we do not need to rule out any option on the basis of a thin external market.

All four options carry a potentially significant impediment—all are politically charged, requiring a careful strategy of analysis, approval, and

implementation. One or more future rounds of BRAC may be at least very helpful, if not necessary, to permit the implementation of some of the options. In the recent BRAC rounds, the military departments have, in effect, given up resources from their prospective budgets and programs in anticipation of BRAC actions. The services buy back that funding through the closure and realignment actions they propose. All closures cost money initially and save a stream of funds later on. The advantage of closing these industrial facilities as a part of a BRAC process is that the BRAC funding covers the initial costs. Facilities declared excess outside of a BRAC require separate, explicit budget tradeoffs.

Principle Underpinning Our Assessment

- Private-sector reliance is consistent with economic principles as well as statutory and regulatory authority
- Rely on the private sector unless overriding considerations dictate otherwise:
 - Inherently governmental activity
 - Market failure—private sector cannot be induced to supply goods
 - National security requirements dictate ownership of assets or control of employees for security reasons or to ensure availability of goods, particularly in time of crisis (expansion capacity)
 - Government can produce goods at lower cost than private sector
 - Long-run cost; net present value

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Our assessment takes as an underlying principle the imperative to rely on the private sector for the provision of the items at hand unless other considerations dictate to the contrary. A presumption of the inherent superiority of private ownership of capital underpins generally accepted principles of cost-benefit analysis and related economic theory. These principles are codified in several statutes.

First, 10 USC 2501 requires that the national technology and industrial base meet its various objectives by “relying to the maximum extent practicable, upon the commercial national technology and industrial base . . .” and “reducing federal government barriers to the use of commercial products, processes and standards.”

Second, 10 USC 2535, which deals with ensuring an adequate defense industrial reserve, complements 10 USC 2501 by asserting the intent of Congress “that to the maximum extent practicable, reliance will be placed upon private industry for support of defense production.” The law also provides for a minimum essential government-owned base, but the statute goes on to say that machine tools and equipment not available in the private sector but needed in time of national disaster may be held in plant equipment packages (in commercial plants) or in a general reserve.

Often cited as conflicting with 10 USC 2501 and 2535 is 10 USC 4532, the Arsenal Act, which requires the Secretary of the Army to “have supplies needed for the Department of the Army made in factories or arsenals owned by the United States, so far as those factories or arsenals can make those supplies on an economical basis.” But the statute also states that the Secretary of the Army may “abolish any United States arsenal that he considers unnecessary.” In the context of the options we are considering in this study, we see no conflict between the Arsenal Act on the one hand and the other two statutes on the other. The Arsenal Act explicitly grants the Secretary of the Army the authority to abolish any arsenal he deems unnecessary. Hence, for our purposes, which involve deciding what capabilities the Army needs to continue to own, the Act presents no barrier to privatizing, consolidating, creating an FGC, or recapitalizing. Once those actions are implemented, the Act still governs decisions related to any remaining arsenals or factories.¹⁸

We offer four countervailing considerations for those who consider the mandate to rely on the private sector. Any one of these factors provides justification for the government to conduct manufacturing in its own factories or arsenals rather than relying on the private sector.

First, the government may not outsource inherently governmental functions. Inherently governmental activities are those that involve governance. They include acts that involve the discretionary application of governmental authority (e.g., command of troops and policymaking). They also include the conduct of monetary transactions that involve public funds (e.g., tax collection, disbursement, and contract administration). OMB Circular A-76¹⁹ specifically cites the manufacture of ordnance equipment as a commercial rather than inherently governmental activity.

Second, the government may need to own manufacturing operations if no commercial producer can be induced to supply needed goods. Such might be the case if commercial producers do not see an acceptable profit margin in the business either because potential producers not currently in the business face high barriers to entry and see insufficient profits to outweigh initial costs or because producers now in the business are unable to make a

¹⁸The wording of the Arsenal Act, “factories or arsenals,” appears to be universally interpreted to include Army ammunition plants as well as the arsenals. Hence, the statute applies to all the activities under study in this phase.

¹⁹U.S. Executive Office of the President, Office of Management and Budget, *Circular Number A-76, Subject: Performance of Commercial Activities*, August 4, 1983 (Revised 1999), p. 2 and Attachment A.

profit. As we later demonstrate in our assessment of options, none of these conditions necessarily obtains for the products at hand.

Third, the government may need to own assets and employ a workforce to ensure continued availability of important capabilities and capacities, particularly in time of crisis. This argument is the one most often presented in defense of continuing to own the land, buildings, and equipment associated with the arsenals and ammunition plants. It is typically argued that GOGO facilities are more responsive to urgent, unforeseen operational demands than contractor-owned or -operated facilities. This logic, if applied to the entire range of Defense needs, would lead to federalization of all Defense manufacturing for which urgent, unforeseen requirements might arise, and that would apply to virtually everything the Defense Department procures. It is also argued that privatization of GOGOs or even GOCOs risks the loss of these assets should their commercial owners go out of business. Yet, most of what the Defense Department procures is manufactured in commercial rather than Defense-owned factories.

The Army is unique among the services in its philosophy of continuing to own factories. All Navy ships are now built in commercial facilities, most of them one-of-a-kind and economically unsuitable for building other types of vessels. Similarly, the Air Force owns no GOGO factories and is divesting of its remaining six GOCO factories. And in the remaining six, contractors own the equipment—the Air Force owns only the land and buildings. Privatization need not risk loss of unique or needed assets. Just as the Army ensures that its organic capabilities remain intact, it must continue to manage the procurement function. Relying on the private sector does not imply that the Army can ignore the viability of the commercial base. The services have a responsibility to ensure that essential private capabilities are maintained. That requires careful oversight and application of financial incentives to ensure the health of the private base.

Finally, it can be appropriate for the government to own assets and employ a workforce if it is inherently more efficient than the private sector in producing goods. Little evidence exists that such is the case. In the GOGO arsenals, in particular, high direct labor charges have been the cause of much consternation. It is true, however, that at GOGO installations where a fixed workforce is underemployed, manufacturing can be done at low marginal costs relative to a private firm whose short-run variable costs include labor. But the prior question this study considers is whether in the long run, these GOGO facilities will be economically competitive.

Assumptions About Need to Own Assets Distinguish the Options

Who should own physical assets?

	Private Sector	Gov't, not Army	Army
Privatize	X		
Create FGC		X	
Consolidate			X
Recapitalize			X

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The fundamental distinction among the options derives from the assumption one makes about who needs to own the land, buildings, and equipment of the enterprise in question. And two options are consistent with the assumption that the Army should own those assets. Secondary assumptions concerning whether the government or private firms should employ the workforce and where the production should occur serve to define the specifics of a particular option.

The privatize option is obviously consistent with the assumption that the private sector is the appropriate owner and employer of production assets. The FGC option is consistent with the notion that for reasons of ensuring capability, the federal government should retain assets, but the Army, whose principal mission lies elsewhere, should not own them. Finally, the consolidate and recapitalize options are consistent with the notions that the Army should retain and manage the production assets. Specific options within the last two may deal with whether the government or private firms need employ workforces.

Privatize: Description of Option

- **Assumptions:**
 - Government has no need to own land or equipment or employ workforce
 - Government can ensure maintenance of necessary capabilities and capacities
- **Specifics of option: Simply get out of manufacturing business**
 - For GOCO plants:
 - Sell installations and equipment
 - Procure ammunition in ways that foster competition and provide predictable, stable workloads
 - Supplement replenishment-required equipment as necessary
 - For GOGO facilities, more complicated
 - Good news, privatization exempt from A-76
 - Exclude Crane (Navy) and McAlester—principally depots, protected
- **Implementation: Either BRAC or non-BRAC (early transfer)**

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Privatization, as mentioned above, is consistent with the assumption that the federal government has no need to own the land, buildings, and equipment associated with production. Implicit in this option is, of course, that the workforce is also private. To be comfortable with this option, one must also believe that the government has the ability to manage procurement in ways that ensure the viability of commercial producers.

Adoption of this option means simply that the government gets out of the business of manufacturing the items in question—ammunition or ordnance materiel or both. The Army offers its plants and equipment for sale and announces that in the future it will buy ammunition or ordnance materiel from competitive bidders.

A decision to privatize does, however, carry with it a responsibility on the part of the government to provide as stable and predictable environment for unique or essential private capabilities as possible. This can be done through smart, multiyear contracting.

To the extent that replenishment demands require some equipment to be maintained but laid away in peacetime, the government must fund the maintenance of that equipment.²⁰

Privatization of GOGO facilities is a bit more complicated. First, as mentioned above, Crane is protected by legislation²¹ that requires all functions performed by government employees when the legislation was enacted in 1986 to always be performed by government employees. More significantly, the Navy, not the Army, owns Crane; the Army is simply a tenant there. McAlester, which is owned by the Army, is protected by the same legislation. Further, these two installations serve principally as depots rather than as manufacturing installations.

But privatization can be accomplished outside of the confines of competitive sourcing rules laid out in OMB Circular A-76.

While the Army could privatize some or all of these activities outside of BRAC, doing so as a part of BRAC offers two advantages, discussed later.

²⁰In discussions with members of the Industrial Committee of Ammunition Producers, it became clear that commercial producers cannot be expected to invest in equipment for layaway because the government cannot guarantee repayment for such investments, and it appears infeasible to add such costs to ammunition contracts. It appears more plausible, however, to contract with producers to maintain equipment procured by the government for use during replenishment.

²¹Section 317, Public Law 99-661, November 14, 1986.

Privatize: Commercial Interest

- Commercial value highly variable from facility to facility
- Both ammunition and nonammunition manufacturers may have interests
- Day and Zimmerman has indicated interest in buying Kansas AAP
- Chamberlain has been interested in buying Scranton AAP
- Most recent transfers at excess plants have been to other government agencies

TRANSFERS TO GOVERNMENT AGENCIES

Badger:	USDA, BIA
Joliet:	VA, Forest Service, County
Kansas:	Fish & Wildlife, USAR
Longhorn:	Fish & Wildlife
Ravenna:	NG
Sunflower:	State of Kansas
Twin Cities:	NG, County, City
Volunteer:	USAR, County

TRANSFERS TO PRIVATE SECTOR

Comhusker:	Local farmers
Indiana:	LRA
Joliet:	LRA

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The commercial value of the 16 installations varies widely according to their location, the extent of commercial activities in the local area, and the extent and quality of the infrastructure on the installations. Both ammunition and nonammunition producers are likely to have an interest in the GOCO plants. The arsenals are likely to be attractive to commercial interests that can enter nondefense as well as defense-related markets. The small size of defense orders relative to the capacities at the arsenals, which are extremely large manufacturing facilities by any standard, would dictate substantial diversification, as we discuss more fully below.

There has been some commercial interest in at least two of the GOCO plants. Recently, the Army has received overtures from Day and Zimmerman about buying Kansas AAP and from Chamberlain Manufacturing about buying Scranton AAP.

Looking historically at the transfer of land at excess ammunition plants, most has been transferred to other federal, state, and local government authorities rather than to the private sector. This in part reflects the process under which the land is transferred, requiring the property to be offered first to government agencies. Use of the early transfer authority (42 USC 9620) could permit land to convey directly to commercial interests.

Privatize: Assessment	
BENEFITS	DOWNSIDES
<ul style="list-style-type: none"> • Supports national policy • Divests of peripheral function • Permits private sector to determine best use of assets • Brings private-sector incentives to bear: efficiency, freedom to act • Maintains employment levels—private 	<ul style="list-style-type: none"> • Army gives up control of assets <ul style="list-style-type: none"> – Responsiveness, smart contracting • Requires management to ensure continued capability • Capital costs may increase prices—offset by increased competition • Political issues for GOGO <ul style="list-style-type: none"> – Government workforces – Crane and McAlester protected
FACTORS NOT Affected	
<ul style="list-style-type: none"> • Peacetime and replenishment capacity <ul style="list-style-type: none"> – Except during transition 	
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A net assessment of the privatization options reveals distinct benefits.

Most important, privatization is consistent with national policies to rely on the private sector to the maximum extent possible. Private sector ownership of assets broadens the set of alternative uses in play for such assets and brings bottom-line, competitive incentives into play.

Nevertheless, one cannot assume that in every case a private provider can produce needed materiel more efficiently. Detailed analysis is required to make that assessment.

Privatization offers the management advantage of divesting the Army of a peripheral function—manufacturing. The Army directs substantial attention to the management of these facilities. For example, the Munitions and Armament Command of the OSC consists of more than 500 civilian employees and a handful of military personnel. Roughly 300 of these personnel are assigned to teams whose duties include the management of these 16 facilities and the production that occurs on them.²² Similarly, a smaller number of personnel at AMC headquarters and at the Department of the Army level are occupied entirely by the management of this function. Privatization would permit the Army to concentrate on one of its essential

²²Authorization document for the Munitions and Armament Command, OSC, AMC, 2000.

functions—procurement of ammunition and ordnance materiel—rather than the ownership and management of factories.

Privatization, particularly of GOGO facilities, has the advantage of reducing federal employment while maintaining and likely even enhancing the level of economic activity and, therefore, civilian employment at converted installations as private-sector incentives take hold.

On the other hand, privatization removes the land, buildings, and equipment from Army control, an issue of concern to many.²³ These concerns follow two principal lines of reasoning.

First, it is argued—usually anecdotally—that only a government-operated facility can offer the responsiveness needed in a crisis. A recent instance in Bosnia is often cited. The commander on the ground identified an urgent requirement to protect occupants of HMMWVs from mines. Rock Island Arsenal received the requirement to design and fabricate these items in a matter of days, and did so. No contracting was required; the federal employees at the arsenal simply went to work without bureaucratic or contractual delay. While this anecdote conveys an important attribute of the GOGO governance at Rock Island, it is not clear that it is unique to GOGO facilities.

On a recent trip to McAlester AAP, two of the authors were briefed on a crisis that occurred in July 2000 in which all the Joint Standoff Weapons (JSOWs) of the Pacific fleet were determined to have a flaw in their payload dispenser rails that required immediate correction. DoD turned to a Raytheon element at McAlester to refit the entire complement of 112 JSOWs. Without bureaucratic or contractual delays, the Raytheon team at McAlester turned to the task immediately. On receiving the weapons on July 10, the team worked around the clock and refitted the entire stock of missiles. Eighteen days later, the missiles were back at Port Hadlock ready for transport back onboard the aircraft carriers. The Raytheon team points proudly to the congratulatory letter of Rear Admiral Jack Chenevey commending the team for their responsiveness and dedication.²⁴ In sum,

²³In particular, the Office of the Under Secretary of Defense (Comptroller), in commenting on an earlier version of this report, takes the position that it may be prudent for the government to maintain some direct control over the manufacture of certain critical items, such as gun mounts and cannon. In such cases, that office would tend to favor a GOCO arrangement over complete privatization. In response, the authors offer the observation that services other than the Army rely to a greater extent than the Army on private provision of even essential systems, including capital ships and aircraft.

²⁴We are indebted to Mike Chitwood of the McAlester Raytheon team for this information.

both sides of the responsiveness issue have merit. Interviews with contracting and procurement authorities lead us to the conclusion that smart contracting and the maintenance of healthy relationships with contractors can ensure responsiveness.

It is also argued that facilities need to remain government-owned to ensure that capacity not needed in peacetime but required for replenishment remains available and in repair. Virtually all laid-away ammunition lines today consist of government-owned equipment, located on government-owned land in government-owned buildings. Most will be operated during replenishment by contractor personnel, although a few lines are in the GOGO ammunition plants. Of the 70 lines needed during replenishment, 63 either are in use today or will be sometime in the next six years, although five of them are used for non-DoD commercial production.

If these functions are privatized, the government would need to establish the same sorts of arrangements it has today with the commercial producers who are maintaining replenishment-required inactive lines at GOCO plants. The government would also need to decide whether to continue to own laid-away equipment or to sell it to contractors for maintenance. If the government decided to continue to own the laid-away equipment, it could be stored at the sites where it is intended to be operated or, if replenishment scheduling permits, it could be stored at desert sites such as Hawthorne, Nev., where weather conditions would be less damaging than at typical ammunition plant sites.

To the extent that producers have out-of-pocket costs as a result of buying land and equipment, the government could be at risk for increased ammunition prices, but those costs could be offset by the increased economic opportunities the buyers might enjoy through ownership.

The external politics of converting GOCO plants to private ownership are likely to be less significant than converting GOGO plants because large government workforces are not involved and particularly since buyers could be expected to increase their economic activity as a result of greater freedom from government controls.²⁵ Privatization of GOGOs is likely to be more difficult, as government workforces are threatened with conversion. Hence, any GOGO privatization seems better suited to BRAC processes.

²⁵For example, one facilities-use contractor has reported to us that he is required to obtain the permission of the OSC before he can agree to bring new tenants on his installation. Such procedures may reduce the extent of tenancy or at least lengthen the process for achieving tenancy agreements.

Except during transition, privatization does not necessarily reduce either currently needed or replenishment-required capacities.

To summarize, privatization appears feasible. Environmental remediation costs, which are potentially substantial, can, through use of early transfer authority, be paid at programmed rates and hence will have no budgetary impact. Further, the environmental remediation liability has been incurred from the use of the land and must be paid regardless of the fate of the installation.

Amendments in 1996 to Section 120h of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC Section 9620h) permits the transfer of property before environmental remediation is completed provided the property is deemed suitable for the intended use and the transfer will not delay the planned remediation.

Create Federal Government Corporation: Description of Option

- **Assumptions:**
 - Government, but not Army, needs to retain control of assets
 - Army benefits from divesting of peripheral function
- **Specifics of option:**
 - Congress enacts FGC; Army divests of assets within scope
 - Congressional action, no need for BRAC
- **Range of implementation options:**
 - Arsenals only; also ammunition plants (real estate)
 - Army conveys all assets to FGC
 - FGC consolidates installations; uses proceeds for capital
 - Army consolidates first, conveys only remaining installations to FGC

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The second option, creation of an FGC to assume all or part of the manufacturing mission, is consistent with a view that the government needs to retain control of the assets and manufacture the required materiel but that the manufacturing function is better conducted by an organization whose principal function is manufacturing.²⁶ In effect, this represents a hybrid, or compromise, option that permits the Army to divest of a nonessential function—manufacturing—while maintaining government control of the function.

Some 70 FGCs and similar enterprises are in operation today. They range from purely financial organizations, such as Fannie Mae, to such organizations as Amtrak and the Postal Service. These entities operate at the boundary between the public and private sectors. They are chartered by

²⁶For a detailed treatment of the various forms of FGCs, see Tighe, Carla E., Carol S. Moore, Alan J. Marcus, Julion Silk, and Robert Trost, *A Privatization Primer: Issues and Evidence*, Center for Naval Analyses, CRM 96-123, January 1997, and Hynes, Michael, Sheila N. Kirby, and Jennifer Sloan, *A Casebook of Alternative Governance Structures and Organizational Forms*, Santa Monica, Calif.: RAND, MR-1103-OSD, 2000.

an act of Congress, typically receiving both a government as well as a commercial mission.

In the case of the Army enterprises at hand, an FGC or related entity could be formed only for Rock Island and Watervliet, as the equipment these arsenals possess has a broader commercial application than the ammunition-manufacturing equipment at the ammunition plants.

Nevertheless, the ammunition plants could be included and chartered to sell ammunition to foreign nations as well as to the U.S. military. Further, the ammunition plants could be included primarily for the commercial value of their real estate holdings, while continuing to house ammunition firms.

The actual conveyance of property from the Army to a newly created FGC could occur in one of two ways. Either the Army could transfer all the property to the FGC, permitting the FGC to spin off unneeded land, or the Army could first consolidate and divest of unneeded land before transferring the remaining assets to the FGC. The first option would permit the FGC to raise capital from sales. The second would yield that benefit to the Army only if the installations are transferred as a part of a BRAC and then only if the property is not claimed first by another federal agency, state government, or local government as prescribed by the Federal Property and Administrative Services Act of 1949. Hence, there appears to be little reason for the Army to spin off facilities before transferring them to an FGC.

What Might an FGC or GSE Look Like?

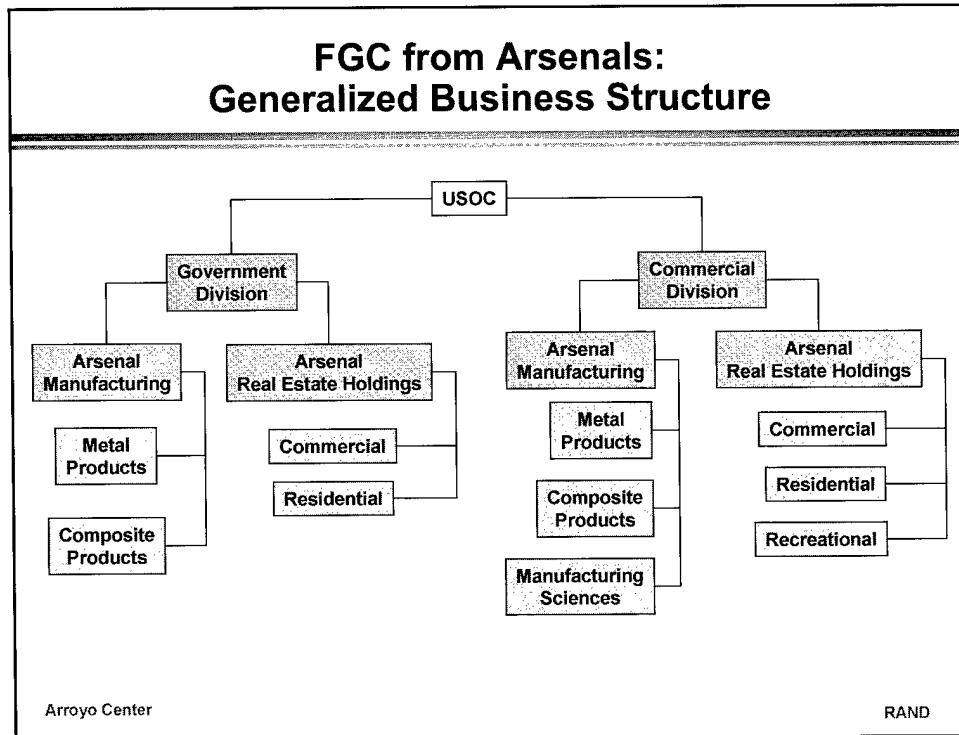
- **Name: U.S. Ordnance Corporation (USOC)**
- **Charter:**
 - Maintain capacity to meet DoD requirements for ordnance materiel (peacetime and replenishment)
 - Provide ordnance-related materiel to DoD and, as authorized, to foreign nations
 - Manufacture and sell nonordnance products as capable
 - Generate revenues that equal costs
- **Management: Board of directors appointed by the President, with the advice of the Senate**
- **CEO: Manufacturing executive**
- **Personnel: USOC employees, not civil service**
- **Tax status: Exempt**
- **Budget: Independent of federal budget**

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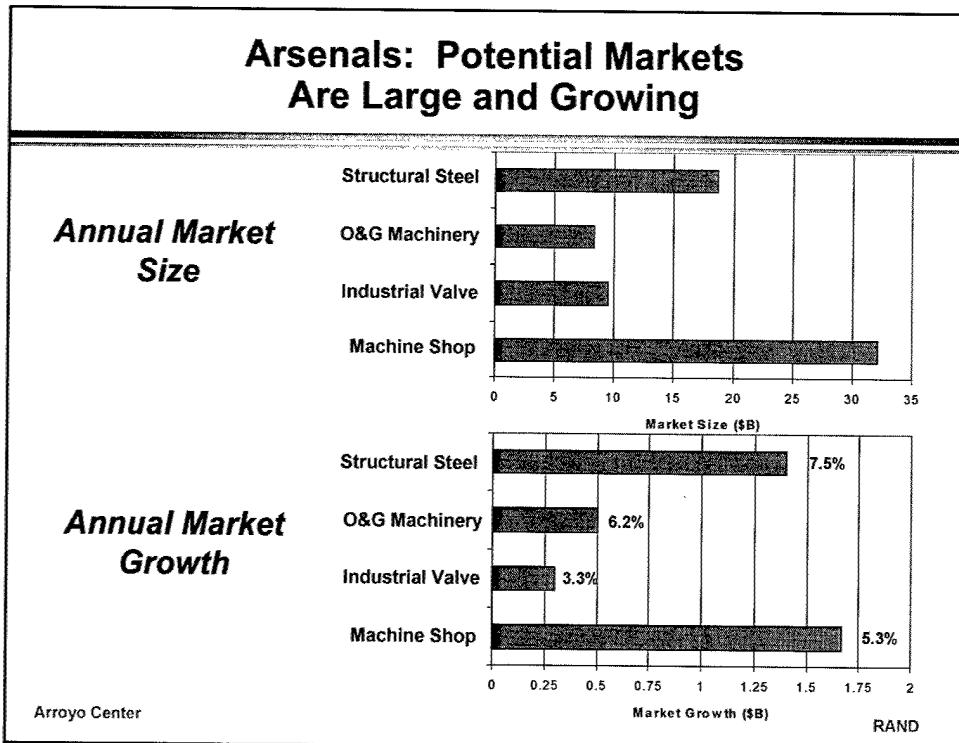
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To illustrate the concept, an FGC might be called the U.S. Ordnance Corporation (USOC). Its charter could require it to maintain the capacity to meet DoD requirements for the products within the scope of its charter (either ordnance materiel of the arsenals or ammunition as well), to sell items as authorized to foreign governments, to manufacture commercial items and market them to the private sector, and finally, to recover its costs. It is the third of these missions, manufacture and sale of commercial items to the private sector, that gives this option an advantage over current operations. WVA and RIA, for example, are unable today to compete successfully for commercial work for two reasons. First, their cost structures do not permit them to be competitive. While repeated reductions in workforce are cutting their fixed costs, declining demand for arsenal products spreads remaining overhead over smaller and smaller production levels. Second, they lack the bottom-line incentives that an FGC would face.

While the government would own the corporation, its financial transactions would be off the federal budget so that its gains and losses would not contribute to the federal deficit or surplus. FGCs are typically tax-exempt, and its employees may be free from civil service personnel rules. Importantly, the chief executive officer could be a manufacturing executive rather than an Army officer whose developmental career typically is spent in other domains.



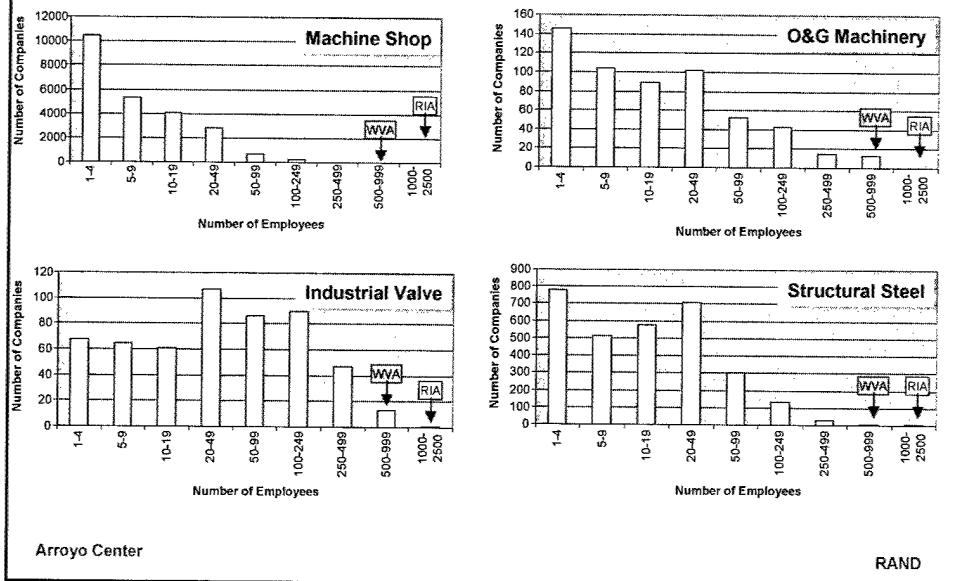
Under the assumption that an FGC would be created only from the two arsenals, the management might consider forming two operating divisions: one to serve government customers, the other to serve commercial customers. The two might have unique cost accounting and overhead structures. Each division might further split its manufacturing and real estate functions and further organize around specific functions within each of these two categories of activities. This structure should be regarded as illustrative rather than prescriptive. It serves only to highlight some of the considerations associated with organizing an FGC to serve government and nongovernment clients.



The first consideration in starting a new business is to determine what business one in fact wants to be in. Such analysis involves not only what internal capabilities an organization may have but also how the prospective markets in which the new business will be involved are structured in terms of market size and growth, the number and size of competitors, profit margins, and the productivity per worker needed to be competitive. The research team did an analysis of more than a dozen prospective heavy industrial markets and selected four in terms of a preliminary look at the manufacturing capabilities of WVA and RIA—machine shops, industrial valve manufacturing, oil and gas field machinery and equipment manufacturing, and fabricated structural metal manufacturing. The data for the analysis are taken from the U.S. Department of Commerce 1997 Economic Census. The market growth rates shown above are assumed to be the same as for the period between 1995 and 1997 and the market size is projected using these growth rates from the 1997 data to 2000. Generally, if the new business does not have some special market entry advantage, one gets into markets that are large and growing rapidly. This entry strategy arises from anticipating how the existing companies in that market are going to respond to a new competitor. If markets are small and growing slowly, the entry of the new business could mean a significant fraction of the market size will be taken from entrenched competitors who can be

expected first to attempt to block the formation of an FGC, then, failing that, to resist the new entrant by predatory pricing strategies, disinformation, and a host of very standard competitive practices. If the market is large and growing at a reasonable rate, chances are that many businesses are in the market already with room for more firms to enter. For example, in a possible business plan for WVA or RIA \$50 million of commercial revenue is required in the first year of operation. For the machine shop market, this is only 0.2 percent of the market size of \$32 billion and only 3 percent of the annual market growth of \$1.7 billion per year. There should be ample room in such a market for a new entrant of this size. Conversely for the oil and gas field equipment market \$50 million represents 0.6 percent of the market size of \$8.3 billion and 10 percent of the annual market growth of \$500 million per year. The competition in this market could react strongly to the presence of a new entrant and will seek to drive the entrant out. However, the profit margins are much greater in the oil and gas field equipment market than in the machine shop market, making it a more attractive long-term target for revenue. A possible business plan for WVA or RIA might start with an entry into the machine shop market, growing into the structural steel market, and subsequently into the oil and gas field machinery and industrial valve markets where the margins are substantially better although the competition is more difficult.

WVA and RIA Are Relatively Large: Would Likely Diversify



The size of a business is driven in large measure by market forces. In a given market, businesses have been forced to be right-sized by economies and diseconomies of scale. In some markets, such as telecommunications, the economies of scale drive businesses to be large. In the heavy industrial markets considered in this analysis, large businesses are very few in number. This indicates that it is very difficult to efficiently operate a large company in these markets. Hence, if the arsenals were to survive in these markets, they might either need to fragment their manufacturing assets or shrink to survive. Consider the machine shop market. If WVA were to enter this market at full strength (524 staff), it would be the second-largest machine shop in the United States. For RIA in this market at full strength (1,258 staff), it would be the largest machine shop in the country.²⁷ The distribution of business size has an important message—large companies do not survive easily in the machine shop market. Consider the structural steel market—here WVA would be among five other companies of similar size whereas RIA would be among three other companies. The message is the

²⁷The total employment figures at the two arsenals may include certain support personnel unique to government operations who would, therefore, not be needed if the arsenals were to be converted to an FGC. Even if half of each arsenal's personnel fell in this category, however, the two would still be unusually large machine shops.

same for the other heavy industrial markets considered in this analysis—smaller is better. The possible business plans for WVA and RIA should have them diversifying their efforts in a number of markets. A vertically integrated manufacturing strategy would be a candidate for such a business plan. A vertically integrated strategy would involve a machine shop division and perhaps an investment foundry division making parts for eventual assembly by the oil and gas field machinery and the industrial valves divisions. All the divisions would be free to use inside or outside suppliers of components and seek business both inside and outside the company. (This would force, for example, the machine shop and investment foundry divisions to keep current with best practices in the marketplace.) This also allows the oil and gas (O&G) machinery and industrial valve divisions to respond to the competitive forces in their marketplaces.

Limitations of FGCs: Accountability

- Unclear congressional charters have led to market discipline issues and accountability issues
- Conflicts between responsibilities of state and private-sector privileges
- Conflicting internal governance problems because of unclear responsibilities of directors and voting rights of government stock
- Off-the-balance-sheet financing can be abused

Better charters can resolve most of these issues

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A central premise in our constitutional form of government is that organizations that implement public policy should be held accountable for their actions. Moreover, public organizations supported by public funds should not benefit private organizations. All benefits from public funds should flow to the public. The FGC sits atop this divide between federal and private roles and responsibilities. Consider the case of a machinist at USOC who posts a notice about a meeting for a political action group on the company bulletin board. The vice president for human resources has the notice removed and admonishes the employee. The employee insists that it be posted because it is a matter of First Amendment rights. USOC has a policy on posting notices allowing the vice president to decide. Is USOC acting as a part of the federal government, which must be bound by the Constitution, or is it acting as a private company within its rights?

Consider the case of a commercial client who sues USOC for nonperformance on a contract. Can USOC claim sovereign immunity and escape any legal remedy? If USOC makes an enormous profit one year, should those profits be returned to the U.S. Treasury? General Electric (GE) proposes a strategic alliance with USOC for heavy industrial machining using existing and new USOC staff. In return for stock and a board membership, GE will build two new facilities, populate them with the most advanced equipment, and provide the workforce with the needed training.

How should USOC respond? Will the government subsidize losses at the FGC? Will it let the FGC go out of business if it can't at least break even? These questions are but a few of the manifold possible issues that can and will arise in the life of USOC. To be prepared with a clear path of action USOC needs a well-crafted congressional charter making clear the roles and responsibilities of the corporation itself, the executive management, and the board of directors. Crafting clear charters for FGCs has not been an area of excellence for Congress in the past many decades. Although Congress has created about one FGC per year since World War II, and although these FGCs have well served the government as instruments of federal policy, this service has been executed with many difficulties. All of these difficulties derive from an unclear path of accountability, to the President, to the Congress, and to the American people. Clarity of charter is the key and is essential to a successful USOC.

Create FGC: Assessment

BENEFITS	DOWNSIDES
<ul style="list-style-type: none">● Divests Army and DoD of peripheral function● Maintains government control of assets—ensures availability● Places assets in hands of organization with bottom-line incentives and entrepreneurial freedom● Avoids political issues of other options	<ul style="list-style-type: none">● Army and DoD lose control of assets● Unusual FGC<ul style="list-style-type: none">– Competes with private manufacturing firms– No commercial market for cannon and ammo, but equipment can make commercial items
FACTORS NOT AFFECTED	
<ul style="list-style-type: none">● Peacetime and replenishment capacity● Government control of assets	

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To recap, the FGC would permit the Army to divest of a peripheral function, while retaining federal government control of manufacturing assets. Further it would place the enterprise in the hands of an organization with stand-alone, bottom-line incentives free from the rules and constraints that accompany federal workforces and activities. Finally, because Congress creates the entity, the option avoids the more difficult political hurdles of other options. Congress either supports the idea or it does not.

On the other hand, the option may appear risky to those who believe the Army should retain control of assets. More substantively, however, the FGC would be somewhat unusual in that it would be competing with private firms in a robust commercial market for commercial items, but in a more restricted market for ammunition. The typical FGC (e.g., Amtrak, Fannie Mae) serves a commercial purpose where it has few competitors. But, such is not always the case. For example, the Postal Service finds itself in an increasingly competitive market for parcels but still enjoys a monopoly on letter mail.

Cost, efficiency, and the ability of an FGC to remain solvent in the face of declining or unpredictable DoD workload become key issues in assessing the FGC. If the cost of guaranteeing DoD workload appeared to be too high, other options, such as a public-private partnership, might be

preferable to the FGC as a means of maintaining some government control over manufacturing capability.

As was the case with the first option, the creation of an FGC would permit required peacetime and replenishment capacity to be retained.

Consolidate: Description of Option

- **Assumptions:**
 - Army should continue to own land, buildings, and equipment at required facilities
 - Current mix of Army and contractor workforce is apt
- **Specifics of option:**
 - Move required capabilities and capacities from closing to receiving installations
 - Divest of land, buildings, and equipment not required
- **Range of implementation options:**
 - BRAC
 - Non-BRAC
 - Divestiture options
 - Standard (excess immediately or generate revenue until clean)
 - Early transfer authority

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Consolidation is consistent with the assumption that the Army needs to retain control of the manufacturing assets—land, buildings, and equipment at hand. Further, the option permits government workforces to continue to operate at the five GOGO sites.

Consolidation simply means relocating manufacturing assets at a smaller number of installations than are in operation today. Land, buildings, and equipment at abandoned sites are divested, either as part of a BRAC or independently. Clearly, consolidating as a part of a BRAC offers both political and economic advantages, as BRAC actions come with money.

Consolidate: Illustrative Example of Economies of Scale

Annual base support costs* \$300 million

Annual production costs* \$600 million

Base Support Assumptions

Close plants whose base support costs = \$100 million

Increase base support costs at receiving installations at 25–50% of closing installations

Annual base support savings = \$50–75 million

Manufacturing Assumptions

Manufacturing costs of plants involved = \$300 million

Manufacturing efficiency increases by 10–20%

Annual manufacturing savings = \$30–60 million

Total annual savings = \$80–135 million

During POM, savings would pay back onetime costs of \$400–675 million

*FY00 estimates.

Sources: For GOGO facilities, FY01 BES; for GOCO, unpublished PWC research

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To illustrate the potential savings that might accrue to consolidation among the 16 facilities, we first observe that the installations collectively require base support costs of roughly \$300 million, gross of offsetting tenant revenues. In FY00, the base support costs of the five GOGO facilities equaled \$231 million; the 11 GOCO plants, \$85 million.²⁸ Annual production costs at all 16 equaled about \$600 million. Consolidations should be expected to achieve savings in both classes of costs.

While we have not tried to estimate the magnitude of such savings in this phase of our research, we show here a range of savings that might be possible. These computations should be regarded as illustrative rather than definitive. First, for base support costs, we assume closure of a hypothetical subset of these installations whose base support costs equal \$100 million of the \$300 million total base support costs. We further assume that the receiving installations will require increases in their base support costs

²⁸Sources: For GOGO plants, Budget Estimates Submission for FY01, Exhibit Fund 22. For the GOCO facilities, unpublished PricewaterhouseCoopers research. In commenting on an earlier draft of this report, the Office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology reported that indirect costs—a broader term than base support costs—are much larger than the \$85 million in base support costs shown here.

equal to only 25 to 50 percent of the costs at the old installations.²⁹ Under these assumptions, such consolidations would result in annual savings of between \$50 million and \$75 million.

Similarly, one could expect the consolidations to generate economies of scale as manufacturing processes and workforces are merged. Assuming the closing and receiving installations had manufacturing costs of \$300 million and that in consolidation these processes achieved efficiency improvements of between 10 and 20 percent, the resulting annual production cost savings would be between \$30 million and \$60 million. To reiterate, this is a purely hypothetical example using actual costs of today's operations simply to provide a feel for what range of savings might be possible.

Together, the annual base support and manufacturing savings in this hypothetical consolidation example would range between \$80 million and \$135 million.

To be bureaucratically and politically feasible, any consolidation scheme necessarily must have initial costs low enough to permit a reasonable payback period. While we have not yet conducted detailed analysis of how much consolidations might cost, we can demonstrate how much the Army could spend and still break even during the seven-year budget and POM period, under the foregoing assumptions. Applying a real discount rate of 4 percent to the streams of \$80 million and \$135 million assumed annual savings, the Army could break even by the end of the POM if it spent as much as \$403 million and \$680 million, respectively. To achieve a positive net present value (breaking even in the long run), the Army could spend between \$1.3 billion and \$2.2 billion.

Fortunately, the 16 ordnance installations have not demolished excess buildings and infrastructure. This offers the opportunity to identify existing structures to receive consolidated equipment, reducing the cost of consolidation relative to earlier BRACs.

Phase 3 is intended to include detailed analysis of specific consolidation options.

²⁹See Bolten, Joseph G., John M. Halliday, and Edward G. Keating, *Understanding and Reducing the Costs of FORSCOM Installations*, Santa Monica, Calif.: RAND, MR-730-A, 1996.

**Consolidate:
Onetime Costs of Recent BRACs Less Than Those
Estimated Supportable Here**

BRAC Round	Action	BRAC COMMISSION ESTIMATES	
		Onetime Costs (\$M)	Annual Savings(\$M)
95	Move Chem & MP to Fort Leonard Wood	231	41
91	Close Fort Benjamin Harrison (to Jackson)	206	37
91	Close Ord (7ID to Fort Lewis)	151	70
95	Realign Letterkenny	50	76
95	Close Oakland Army Base	37	16
95	Move CRTA & NWTC to Fort Wainwright	23	18
95	Move CAA to Fort Belvoir	3	<1

All actions were estimated to pay back within POM

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Again, although we have not yet estimated the onetime costs of specific consolidations, we can observe that estimates of other consolidations in recent BRACs fell well below the \$400 million to \$680 million estimate in the previous figure. The largest of those shown on the figure—the consolidation of the Chemical and Military Police Schools with the Engineer School at Fort Leonard Wood and the consolidation of the activities at Fort Benjamin Harrison with those at Fort Jackson—were anticipated by the BRAC Commission to cost approximately \$200 million, about half the costs hypothesized above.

Consolidate: Assessment

BENEFITS	DOWNSIDES
<ul style="list-style-type: none">● Enhances Army image● Saves base support costs● Returns facilities for other uses● Improves manufacturing flexibility and efficiency● Offers opportunity to recapitalize	<ul style="list-style-type: none">● Fails to increase private-sector reliance● Onetime costs<ul style="list-style-type: none">□ BRAC covers● Administrative issues<ul style="list-style-type: none">□ Environmental permits□ Long-term contracts● Politically difficult without BRAC
FACTORS NOT AFFECTED	
<ul style="list-style-type: none">● Peacetime and replenishment capacity<ul style="list-style-type: none">□ Except during transition● Government control of assets	

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Even if the consolidation conveyed no long-term economic advantage, it would enhance the Army's current image that it lags behind the other services in taking advantage of the last four rounds of BRAC. Of the 97 major installations closed in the last four rounds, the Army has closed only 23.³⁰ Most dramatically, in the 1993 BRAC round, the Navy closed 20 major installations, the Air Force six, and the Army only one—Vint Hill Farms.

But consolidation does offer efficiency opportunities, as described above. Further, consolidation returns unneeded facilities to the public and private domains for their best uses. Finally, consolidation offers opportunities to recapitalize aging or inefficient equipment as part of the actions, potentially enhancing manufacturing flexibility and efficiency.

On the negative side, consolidation maintains assets in public hands and, therefore, fails to move in the direction of private-sector reliance. Although consolidations would necessarily have to achieve long-term efficiencies to be bureaucratically viable, they will incur initial costs that must compete with other Army and Defense priorities. The continuing execution of long-term facilities-use contracts is increasing the cost of getting out of facilities

³⁰U.S. General Accounting Office, *Military Bases: Lessons Learned for Prior Base Closures*, GAO/NSIAD-97-151, July 1997, pp. 57-58.

later. Further, the transfers of functions from one installation to another will incur administrative costs and uncertainties. In particular, environmental permits will need to be renegotiated. This could become a significant factor in determining which activities to move.

Unlike privatization and creation of an FGC, consolidation onto fewer installations may entail an increase in vulnerability to sabotage or terrorist acts. We have not assessed the extent of this increased vulnerability.

Further, the movement of production introduces some short-term risk that equipment might not perform as intended and that skilled personnel will not relocate, resulting in a loss of expertise.

Analysis of consolidation options also requires consideration of nonmanufacturing activities that occur on these installations. For example, several of the ammunition plants store ammunition. Further, the Army derives benefit from the co-location of Watervliet Arsenal and Benet Laboratories. The relationship enhances the Army's ability to develop technology, designs, and manufacturing processes. Any consolidation onto or away from Watervliet should take this benefit into account.

Like the first two options, consolidation will not necessarily affect the capacities or capabilities now resident in the base, except during transition.

Recapitalize and Unify: Description of Option

- **Assumptions:**
 - Army needs to continue to own assets
 - Army transformation and attendant technology dictate refacilitizing
 - Army elects broad strategy of divesting of small, single-function installations
- **Specifics of option:**
 - Close single-function ammo and ordnance installations
 - Recapitalize required organic capabilities on small number of enduring, multifunctional installations
- **Range of implementation options:**
 - Near-term: BRAC
 - Long-term: develop vision and strategy; build support—patience and persistence

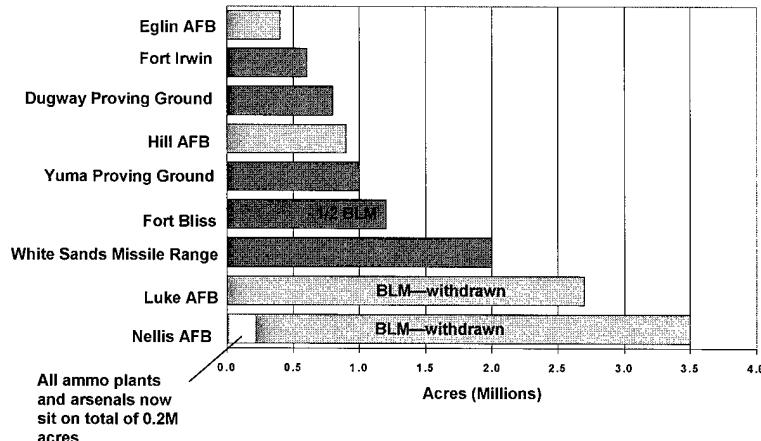
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Recapitalizing the base and unifying it internally as well as with other Army and DoD functions is consistent with the assumption that the Army needs to continue to own the assets of the current organic base. Further, it is consistent with the assumption that at some time in the future, Army transformation and the attendant technology will necessitate getting new facilities for the organic base. Finally, the option would complement any future Army basing strategy that divests of small, single-function installations.

The option envisions closing existing single-function GOGO and GOCO facilities and recapitalizing the activities at larger, enduring, multifunctional installations. In the near term, some recapitalization could be done as part of BRAC, or it could be done later as a part of a broader Army stationing vision.

Where We Might Recapitalize and Unify the Base



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Many DoD installations could eventually house all or part of the manufacturing activities on the 16 installations under review here. These 16 now comprise about 200,000 acres. Several Air Force and Army installations sit on more than a million acres and an equal number occupy more than 500,000 but fewer than 1 million acres. Most of the land attributed to Nellis and Luke and half of that attributed to Fort Bliss actually belongs to the U.S. Bureau of Land Management (BLM) and is withdrawn from the public domain for extended and renewable periods, typically 20 to 50 years. To use this land for the manufacturing purposes envisioned here, DoD would be required to gain special permission. But, as the figure shows, even without these three facilities, plenty of other space is in the inventory. Further analysis is required to determine the practicality of actually using these installations for manufacturing ordnance materiel. This figure simply illustrates that the land on which the current organic base sits represents only a tiny fraction of land owned by DoD—now about 25 million acres.

Recapitalize and Unify: Assessment	
BENEFITS <ul style="list-style-type: none"> • Substantially improves manufacturing flexibility, efficiency, and responsiveness • Recapitalizes aged (World War II) equipment • Facilitates transformation • Saves substantial base support costs 	DOWNSIDES <ul style="list-style-type: none"> • No move toward privatization • May be unnecessary depending on technological change • Substantial onetime costs
FACTORS NOT AffECTED <ul style="list-style-type: none"> • Peacetime and replenishment capacity <ul style="list-style-type: none"> – Except during transition • Government control of assets 	
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To summarize, recapitalization would permit the greatest improvement in efficiency, flexibility, and responsiveness of the three government ownership options. Recapitalization would facilitate any changes in manufacturing necessary to support new weapons technologies and could save substantial base support costs, because the base would share the infrastructure at existing, enduring installations. In the extreme application of this option, no stand-alone ammunition plants or arsenals would remain.

The option makes no moves toward privatization and is not yet proven to be necessary. The complete recapitalization would entail substantial onetime costs: to move, to construct buildings at receiving installations, and to purchase new equipment.

In sum, this option carries with it the highest onetime costs and, of the three government ownership options, provides the greatest potential benefit.

To the extent that these facilities are recapitalized onto installations that are more vulnerable than today's, an increased liability for sabotage or terrorism could occur. On the other hand, receiving installations could implement any desired level of physical security for the transferred activities.

Like the other three options, recapitalization need not diminish current capacities or capabilities.

Pure Strategies: Preliminary Comparative Assessment

Assessment Criteria	Options				
	Status Quo	Privatize	Create FGC	Consolidate	Recapitalize
Mission Fulfillment <small>Programmed requirements Replenishment Responsiveness Certainty of capability Technology advancement</small>	All options retain necessary capacity—programmed and replenishment Privatizing <i>could</i> reduce the certainty of capability— <i>must manage</i> Recapitalizing enhances responsiveness and advances technology				
Financial <small>Net present value Revenues Operating Costs Transition</small>		Best in long run	Bottom-line incentives	Could recapitalize	Achieves efficiencies (Gov't)
Managerial Ease <small>Workforce management Process management Entrepreneurial flexibility Access to capital</small>		Best	Almost as good	Little help	New processes
Statutory Compliance <small>10 USC 2501 10 USC 4532 10 USC 2535</small>		Only option that helps			
Regulatory Consistency <small>AR 700-90 Policy Letter 98-1</small>		Only option that helps			
External Issues <small>Congressional support Union and job concerns State and local politics</small>		GOGO difficult	Unknown. Perhaps easy	GOGO difficult	Most difficult

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In August, the SAG approved a set of six criteria by which options are to be assessed. The six are not equally important. It was agreed that the first of those listed here—mission fulfillment—is clearly the most important. Any option that poses a substantial risk to the production of items programmed or later required during replenishment following two MTWs would be at a distinct disadvantage relative to options lacking such risks.

The lightly shaded boxes indicate the best option by that criterion. The darker boxes indicate the least desirable option.

Mission fulfillment consists of five subordinate evaluation criteria: ability to meet programmed and replenishment missions, ability to respond rapidly to unforeseen demands, the certainty that needed capacity will remain available when needed, and the extent to which the option will foster the inclusion of advanced manufacturing technology. We assess all five options, including the status quo, as having roughly equal likelihood of meeting both programmed and replenishment demands. While privatizing all or part of the base would have the potential to reduce capacity and therefore inhibit the ability to meet demands, we feel that the privatized base can be managed in ways that ensure the continued existence of needed capacity. We note that all Navy ships are manufactured in completely private yards that the Navy manages intensely to ensure the continuance of

needed capabilities. These highly specialized shipyards are useful only for the construction of the warships they make. They are not commercially useful. And the Air Force is in the process of privatizing all its remaining six GOCO manufacturing facilities. Most Army vehicles, weapons, and equipment are today manufactured in private facilities. And, as noted earlier, most of the Army's ammunition procurement dollars already go into private rather than organic facilities. Privatization of part of the remaining organic base would represent merely a further shift toward what is already the dominant manufacturing mode of defense production. With regard to the last of the mission fulfillment criteria, the recapitalization option has the greatest potential to introduce new technology, although the other options do not preclude it.

With regard to the second criterion—financial—the principal measure of merit is long-term net present value. In other words, the long-term net benefit, taking into account the time value of money. Although net present value is the accepted economic metric, in the Defense Department's programming and budgeting processes, payback period can be the determining factor, causing an option with a less impressive net present value but a short payback period to be favored over one with converse properties. At this point our assessment is based simply on a subjective assessment of potential costs and savings. The actual site-specific cost analysis is deferred until Phase 3. Nevertheless, at this point we suggest that the privatization option offers the best potential economic benefit because it is the one that most fully brings market forces and private-sector competitive incentives to bear. The creation of an FGC may prove a close second. Despite the constraints that a government charter may impose of an FGC, it would enjoy many of the economic advantages of a completely private firm, including the economic incentives to use the assets to make and sell commercial items to the private sector. On the other hand, any legislation that would mandate procurement from the FGC would tend to lessen those incentives.

The third criterion—managerial ease—takes into account an option's potential to enhance the ease of management of a workforce, improve processes, bring entrepreneurial incentives to bear, and provide access to capital. Privatization appears to offer the greatest potential, and the FGC option may be nearly as good. Both the Army-owned options for change appear inferior, although recapitalization would introduce new processes.

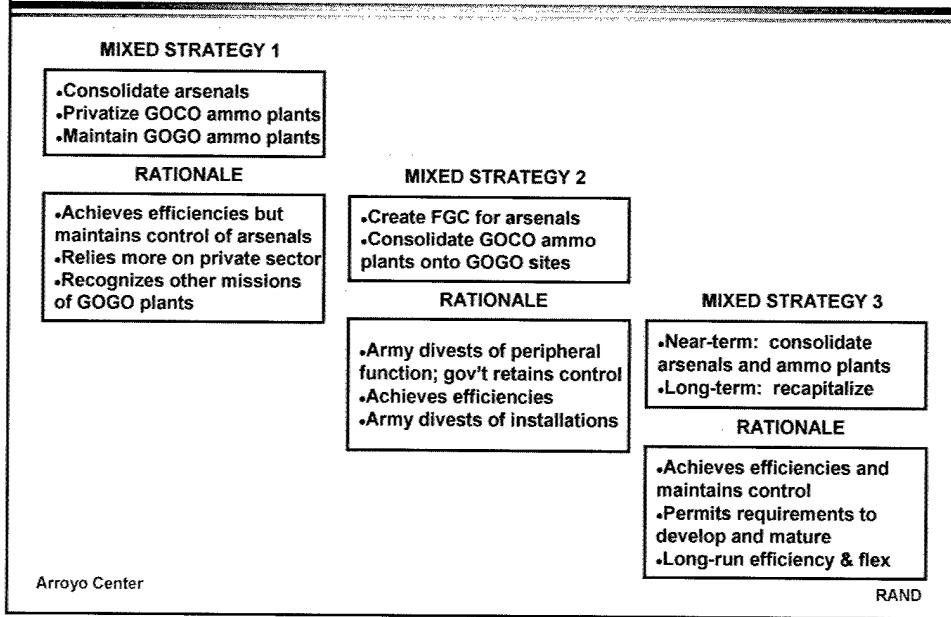
The three statutes cited in the fourth criterion—statutory compliance—either dictate reliance on the private sector or the use of economic efficiency

as a criterion for placing work. Similarly the two citations under the fifth criterion—regulatory consistency—also encourage private-sector reliance.

Only the privatization option moves toward increased private-sector reliance.

Finally, external issues encapsulate the set of political issues surrounding the options. Obviously, it is politically easiest to maintain the status quo. Privatization may be the most difficult option around which to achieve political agreement because so many diverse political interests would be affected. Both privatization and consolidation would be difficult at the GOGO facilities because of the strong political power of the government workforces.

Mixed Strategies Are Likely To Be Appealing: Illustrative Examples



Because of the heterogeneous nature of the 16 installations, a set of mixed strategies is likely to emerge from the Phase 3 analysis. Here, we suggest only three of a large number of possibilities simply to illustrate the concept.

Mixed Strategy 1 envisions consolidation of the two "hard iron" arsenals at one location, privatization of the GOCO ammunition plants, and maintaining the three GOGO ammunition plants as they are today. This option is consistent with the assumption that the underused arsenals can achieve economies of scale from consolidation but are best left in GOGO status to ensure responsiveness in unforeseen conditions. At this point in our analysis, this relative responsiveness on the part of government-operated facilities remains an assumption rather than a fact. The option permits greater reliance on the private sector through the privatization of some or all of the GOCO ammunition plants but accepts the GOGO ammunition plants on the grounds that their principal functions, ammunition depot operations, dictate their durability. The option also recognizes the protective legislation that applies to Crane and McAlester. The Army could, however, seek relief from that legislation.

Mixed Strategy 2 would create an FGC from the two "hard iron" arsenals under the rationale that the Army should relinquish manufacturing to an organization whose central function is manufacturing but that the

government needs to own that organization to ensure continuance of the assets and the responsiveness that government ownership may convey. At the same time, the option would consolidate the GOCO plants onto one or more of the more enduring GOGO ammunition sites to achieve economies.

Mixed Strategy 3 reflects a time-phased approach. Early on, the GOCO plants and arsenals consolidate where reasonable to achieve efficiencies while in the long term a recapitalization strategy is developed.

Conclusions

- **All four options:**
 - Offer advantages over the status quo; they also carry downsides
 - Appear feasible
- **Replenishment capacity not at issue—all options can maintain necessary capacity**
- **Replenishment requirements process should be streamlined and its assumptions validated**
- **Mixed strategies permit reaping some benefits of each option; avoid downsides**
- **Future BRACs offer possibly unique opportunities**

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In sum, at this point in our research all four broad options remain feasible. Each offers certain distinct advantages over the status quo. Similarly, each brings with it certain downsides.

None of the options necessarily threatens the ability to meet both programmed and replenishment requirements. Excess capacity can be divested in all options, but, as we learned in Phase 1, such divestiture saves little. The cost of continuing to own excess equipment already paid for is low.

The replenishment requirements process takes more than two years to complete and is based on generous assumptions. The process should be streamlined and its assumptions rationalized.

Mixed strategies are likely to be favored over any pure strategy because of the unique properties of the various installations and the unique activities they house.

One or more rounds of future BRACs, if they occur, will offer perhaps unique opportunities to achieve otherwise difficult changes. Further, such BRACs provide a means of funding these changes.

APPENDIX A—PERSPECTIVES ON THE ARMS PROGRAM

This appendix discusses the Armament Retooling and Manufacturing Support (ARMS) initiative. We first present background on the program. Second, we present and discuss data provided to us by Operations Support Command (OSC) on the history of ARMS expenditures as well as its resulting benefits. Next, we present concerns we have heard about the ARMS program. We conclude by discussing the possible future evolution of this program.

BACKGROUND

The ARMS program was created by Public Law 102-484, enacted in October 1992. It was a subtitle of the National Defense Authorization Act for Fiscal Year 1993.³¹ Table A.1 summarizes its major provisions. The legislation includes a mix of socioeconomic (e.g., assistance to small businesses and depressed regions) and military (e.g., maintenance of critical skills) objectives. There is no clear guidance as to how to trade off these objectives, should they conflict. (There does, however, appear to be a greater comparative emphasis on socioeconomic, as opposed to military, factors, at least in tallying the number of mentions in the legislation.)

The original ARMS Act does not discuss funding, so there is no discussion, for instance, of a requirement that expenditures related to the ARMS Act have favorable financial return.

Until FY01, the program applied only to Army ammunition plants. The FY01 National Defense Authorization Act (Section 343) created an Arsenal Support Program Initiative intended to help maintain the viability of the arsenals. The measure authorized a demonstration program in part to encourage commercial firms to use the arsenals for commercial purposes. It is too early to assess this new initiative.

³¹Codified as 10 USC 434.

Table A.1
Selected Provisions of the Armament Retooling and Manufacturing Support Initiative

Section	General Provisions
191	Subtitle may be cited as the Armament Retooling and Manufacturing Support Act of 1992
192	<p>It is the policy of the United States</p> <p>To encourage nondefense firms to use ammunition plants</p> <p>To use such facilities to promote competition in the United States and global marketplaces</p> <p>To increase manufacture of products currently produced outside the United States</p> <p>To support policies and programs that provide incentive to manufacturers to use government plant and equipment for commercial purposes</p> <p>To provide small businesses with incentives to undertake manufacturing</p> <p>To encourage creation of jobs through increased investment in the private sector</p> <p>To foster a more efficient, cost-effective, and adaptable armaments industry</p> <p>To achieve an optimum level of readiness of the defense industrial base</p> <p>To encourage facility contracting where feasible.</p>
193	<p>Purposes of ARMS initiative are</p> <ul style="list-style-type: none"> - To encourage commercial firms to use government-owned ammunition facilities for commercial purposes - To increase opportunities for small businesses - To reduce the adverse effects of reduced Army spending on communities - To provide for the reemployment and retraining of skilled workers who are idled or underemployed - To contribute to the attainment of economic stability in economically depressed regions - To maintain a work force skilled in manufacturing processes - To be a model for future defense conversion initiatives - To allow ammunition facilities to be rapidly responsive to market competition - To encourage relocation of industrial production from outside the United States
194	<p>The Secretary of the Army may authorize the facility contractor</p> <ul style="list-style-type: none"> - To use the facility for one or more years - To enter into multiyear contracts for commercial use of the facility <p>The facility contractor is the contractor authorized to manufacture ammunition and components at the facility and is responsible for the overall operation of the facility in the event of industrial emergency</p>
195	<p>The Secretary of the Army must report on the ARMS initiative</p> <ul style="list-style-type: none"> - Review contracting under the ARMS initiative - Recommend changes

OSC set up a process to implement ARMS. Each ammunition plant has a facility contractor, as shown on Table A.2. As discussed in Section 194 of the ARMS Act, the facility contractor is responsible for performing each plant's replenishment mission. The facility contractor also serves as the interface between prospective tenants and OSC. Individual tenants have agreements with the facility contractor, not with OSC. Similarly, OSC's agreements are with the facility contractor, not with individual tenants.

To initiate an ARMS project, a facility contractor identifies a prospective commercial tenant. The facility contractor negotiates a deal with that tenant. One stipulation of the facility contractor-tenant arrangement is what improvements (if any) need to be undertaken at the ammunition plant to make the arrangement acceptable to the tenant.

Tenants pay rent to facilities contractors, not to the government. Contractors do not then pay money to the government. Instead, the contractors perform in-kind services, the dollar value of which is estimated and counted as a benefit to the government.

Table A.2
Ammunition Plants and Their Facility Contractors

Plant	Facility Contractor
Holston	BAE Systems Ordnance Systems
Iowa	American Ordnance, General Dynamics/Day & Zimmerman joint venture
Kansas	Day & Zimmerman
Lake City	Alliant Techsystems (ATK)
Lone Star	Day & Zimmerman
Louisiana	Valentec Systems
Milan	American Ordnance, General Dynamics/Day & Zimmerman joint venture
Mississippi	Mason Technologies (MTI), subsidiary of Day & Zimmerman
Radford	Alliant Techsystems
Riverbank	Norris Industries
Scranton	Chamberlain Manufacturing Corporation

With such a proposed deal in hand, the facility contractor contacts OSC. OSC is then asked to decide whether the arrangement is acceptable, including, in most cases, whether OSC is willing and able to expend ARMS funds to the requested level. (In the next section of this appendix, we present OSC-provided data on the history of ARMS cash flows to date.)

OSC, we learned, has a "checklist" system for evaluating proposals it receives. Proposed projects are granted "points" based on their desirability, with 20 points being the cutoff for approval. Table A.3 shows their point scale. Proposals are rated more highly if they create more jobs, maintain critical skills for the plant, have rapid recovery of government funds, involve commercial work, or accord with government socioeconomic objectives. These points are clearly tailored to the disparate objectives of ARMS set forth in the original legislation described in Table A.1.

The checklist's scoring system is not binding. Instead, we learned, the checklist *de facto* creates a presumption either for or against a proposal. OSC personnel can use their judgment to override a checklist, with the approval of an Overarching Integrated Product Team (OIPT) consisting of OSC's Chief Counsel, OSC's Acquisition director, and the Chief of the Munitions and Armaments Center.

OSC personnel indicated they have overturned a number of checklist-suggested decisions. For instance, they have fielded numerous proposals to build landfills on ammunition plants that have scored well. These proposals have been rejected, with the approval of the OIPT.

ARMS EXPENDITURES AND BENEFITS

OSC provided us with data on the history of ARMS expenditures as well as their estimates of the benefits that have accrued heretofore to the Army from these up-front expenditures.

Table A.4 presents OSC-provided data on cumulative ARMS expenditures by ammunition plant, through December 31, 1999. We caution that the data represent sums of then-year dollars. In other words, a plant with \$1 million expended in 1994 and \$1 million expended in 1999 would show \$2 million total expended, notwithstanding that, in an appropriate discounting sense, 1994's \$1 million was more costly to the Army and the federal government.

Table A.4 does not include roughly \$2.5 million OSC has spent to date administering the program. Table A.4 does include incentive award fees that OSC has provided to facility contractors who have done good jobs attracting tenants.

In FY00, the ARMS program received about \$24 million in funding. The Army has traditionally requested much less for the program (e.g., \$5 million per year), but Congress has repeatedly chosen to budget more than the Army's request.

Table A.3
ARMS Proposal Evaluation Criteria

Criteria	Level	Points
Projected Three-Year Employment	Less Than 10 Jobs	1
	11–20 Jobs	2
	21–30 Jobs	3
	31–40 Jobs	4
	41–50 Jobs	5
	51–60 Jobs	6
	61–70 Jobs	7
	71–80 Jobs	8
	81–90 Jobs	9
	More Than 90 Jobs	10
Skills Maintained	1 Critical Skill	2
	2–3 Critical Skills	4
	4–5 Critical Skills	6
	6–7 Critical Skills	8
	More Than 7 Critical Skills	10
Return on Expenditure	Less Than or Equal to 5-Year Recovery Time	10
	6-Year Recovery Time	9
	7-Year Recovery Time	7
	8-Year Recovery Time	4
	9-Year Recovery Time	2
	10-Year Recovery Time	1
	11-Year Recovery Time	0
Type of Work	OSC Workload	0
	DoD/Third Party	3
	Other Government	5
	Direct Sales	8
	Commercial	10
Other Factors	Small Business	3
	Minority Business	3
	Relocate from Overseas	7
	Guaranteed Payback	10

SOURCE: OSC.

Table A.4
ARMS Expenditures Through December 31, 1999

Plant	Cumulative Expenditures (\$ Millions)
Badger	0.6
Holston	9.0
Indiana	24.3
Iowa	22.5
Kansas	1.1
Lake City	0.4
Lone Star	1.1
Longhorn	1.0
Louisiana	3.5
Milan	1.0
Mississippi	44.0
Radford	51.0
Riverbank	16.5
Scranton	1.0
Sunflower	9.5
Volunteer	10.0
 Total	 196.5

SOURCE: OSC.

Table A.4 shows marked heterogeneity in the amount of ARMS expenditures at different plants. Several explanations exist for this phenomenon. First, the plants vary in terms of their attractiveness to potential tenants. Some plants are in more desirable locations, from tenants' perspectives. Some plants produce goods better suited to alternative private-sector use. Some plants have better existing facilities and equipment. (Better existing facilities and equipment increase the allure of a plant to tenants. The effect on ARMS expenditures, however, is ambiguous since a modern facility might therefore require fewer additional expenditures to attract tenants. On the other hand, a very poor facility may require so many additional expenditures as to make it not cost-effective to undertake requisite renovations to attract tenants.)

Another factor is that OSC perceives that different plants' facility contractors have shown differing levels of aggressiveness in attempting to attract tenants to the plants.

ARMS funds were spent on various plant improvements. For instance, buildings were upgraded to modern safety and access standards. Another category of expenditure has been environmental improvements for tenants. Examples of such endeavors have included demolition of excess buildings, asbestos removal, lead-based paint removal, and removal of underground tanks. OSC personnel estimated that approximately one-third of ARMS expenditures have gone for such environmental purposes.

These environmental expenditures are interesting in that they involve, at least in part, the sorts of cleanup efforts the Army would have to undertake prior to disposing of a plant. (On the other hand, it could be that plant disposal would involve cheaper environmental remediation processes than those that ARMS has funded.) Alternatively, if the plant were kept forever, the Army would be required to eventually fund these expenditures.

Some slice of ARMS expenditures, therefore, is not a net expenditure associated with bringing tenants to the plants. Instead, such expenditures represent the addressing of what would otherwise be a long-term Army liability.

The other side of ARMS is the benefits the Army accrues from the program. Table A.5 shows OSC-provided data on cumulative and annual ARMS benefits by plant. We also include Table A.4's tabulation of ARMS expenditures to juxtapose with these data.

FY00's projected \$32 million benefit is an increase from FY99's \$28 million estimated benefit.

As noted above, we caution that both cumulative columns represent sums of then-year dollars and are not appropriately discounted. This shortcoming implies the benefits are overstated in comparison to the expenditures in that the expenditures preceded the benefits.

Kansas stands out as being particularly successful in Table A.5. Doug Borgeson of OSC told us that Day & Zimmerman at Kansas has a series of long-term relationships with foreign governments that have proven to be lucrative at this facility.

Table A.5
ARMS Benefits

Plant	Projected	Cumulative	
	2000 Benefits (\$ Millions)	through 2000 (\$ Millions)	Cumulative Expenditures (\$ Millions)
Badger	0	0.4	0.6
Holston	0.3	0.4	9.0
Indiana	2.0	17.7	24.3
Iowa	2.2	14.1	22.5
Kansas	1.8	17.0	1.1
Lake City	0.2	0.3	0.4
Lone Star	0.1	1.1	1.1
Longhorn	0	0.4	1.0
Louisiana	1.3	3.7	3.5
Milan	0.5	1.1	1.0
Mississippi	5.3	17.6	44.0
Radford	14.0	65.1	51.0
Riverbank	1.5	5.0	16.5
Scranton	2.2	6.3	1.0
Sunflower	0.4	5.4	9.5
Volunteer	0.6	5.1	10.0
Total	32.4	160.7	196.5

SOURCE: OSC.

Even if one could correct for discounting shortcomings, it is not clear when or whether the ARMS's cumulative benefits will catch up with or exceed the cumulative expenditures. For example, we do not know at what rate the ARMS-funded improvements are depreciating in value. We do know, however, that the intent of the ARMS program is for either the tenant or the facilities-use contractor, depending on the agreement, to maintain and upgrade occupied facilities. Hence, to the extent that maintenance standards are sufficient and adhered to, no depreciation should occur. Obviously, it would be best if the expenditures resulted in improvements that benefit the Army for many years. We do not have information, however, as to the expected or realized longevity of these benefits. Further, we observe that requiring tenants to perform maintenance is an unusual arrangement.

ARMS benefits accrue to the Army in different ways. One approach is that OSC negotiates a reduction in ammunition prices from a contractor in exchange for ARMS expenditures. Table A.6 illustrates this phenomenon, showing discounts on two items, at a plant we will call Ammunition Plant X,³² the facility contractor has agreed to in exchange for ARMS funding, according to information provided by OSC.

Another form of benefit to the Army is when facility contractors agree to provide "consideration." A consideration is when the facility contractor agrees to perform, at no additional cost to the Army, some plant upgrade the Army has requested. The monetary benefit attributed to considerations is subjective and not transparent.

A third form of benefit is when a facility contractor agrees to a reduction in the level of Maintenance of Inactive Industrial Facility (MIIF) funding in exchange for ARMS funds. For example, OSC indicated the current scope of work (what the facility contractor, MTI, is actually spending) at Mississippi is about \$6 million per year. MIIF to MTI in FY00 was about \$800,000. OSC reports that for FY01, the negotiated cost to the Army is zero. Table A.7 shows actual and projected MIIF levels by plant and year. ARMS advocates would claim the aggregate downward trend emanates, at least in part, from the program. On the other hand, the observed decline may also emanate from reduced requirements or the Army simply assigning a lower priority to maintenance of these facilities.

Table A.6
ARMS-Generated Price Discounts at Ammunition Plant X

Product	Annual Quantity	Price with ARMS	Price Without ARMS	Annual Savings
Product A	2,725	\$626	\$680	\$147,150
Product B	50,000	\$57	\$64	\$350,000

SOURCE: OSC.

³²We mask the identity of the plant and the products involved at the request of OSC to protect privileged information. Further, it should be noted that these discounts are Army estimates of the savings. They exclude the cost of the appropriated ARMS funds.

Table A.7
MIIF Funding (\$ Millions)

Plant	FY99	FY00	FY01	FY02	FY03
Badger	1.245	1.076	0.750	0.750	0.750
Holston	2.326	1.756	1.705	0.000	0.000
Indiana	0.389	0.920	0.300	1.337	1.112
Iowa	0.360	0.532	0.320	0.502	0.441
Kansas	0.000	0.000	0.000	0.000	0.000
Lake City	0.025	0.000	0.000	0.000	0.000
Lone Star	0.216	0.189	0.270	0.250	0.200
Longhorn	0.512	0.381	0.422	0.400	0.400
Louisiana	1.118	0.904	0.800	0.700	0.421
Milan	0.157	0.134	0.166	0.150	0.150
Mississippi	1.569	0.787	0.000	0.000	0.000
Radford	1.508	0.994	1.500	1.350	1.172
Riverbank	1.499	1.253	0.831	1.100	0.900
Scranton	0.222	0.000	0.250	0.000	0.000
Sunflower	0.000	0.075	0.737	0.463	0.463
Volunteer	1.292	1.462	1.885	1.550	1.400
Total	12.438	10.463	9.936	8.552	7.409

SOURCE: OSC.

OSC and the Army do not get direct payments from plants' tenants. Instead, the tenants pay the facility contractor, with OSC having visibility over the facility contractor's accounting records.

Appropriately tabulating the benefits accruing to the federal government from ARMS is not trivial. One problem is that having tenants at plants raises plants' expenses by some unknown amount. For instance, the facility contractor might spend more on roof maintenance than would be the case absent tenants. Also, expenses associated with marketing are clearly driven by the desire to acquire tenants.

OSC personnel conceded this point, but suggested the magnitude of tenant-driven cost increases (beyond marketing) was minor. For instance, most plants have utility systems operating vastly below capacity. Hence, the incremental cost of providing utilities to tenants is very low. Also, some tenants maintain their own buildings, suggesting facility contractor and

Army costs are reduced, rather than increased, by their presence. Tenant-provided in-kind services are a category of benefit that accrues to the Army from ARMS, but are not captured in Table A.5's list of ARMS benefits.

Bolten, Halliday, and Keating (1996) analyzed the relationship between the military populations of active-duty Forces Command installations and installations' expenditures. They found only limited evidence that expenditures for base support functions increase with installation populations. OSC's argument that tenants only have limited impact on plants' costs is analogous.

Not all the benefits shown in Table A.5 are appropriately counted as benefits of the ARMS program. Some tenant revenues would have occurred even without the program. Further, tenant services the Army would not have performed itself (e.g., levels of maintenance above Army standard) should not be counted as a benefit. Finally, any tenant revenue that facilities-use contractors either spent on marketing or retained as profit should be excluded.

Only tenant revenues that actually reduce government expenditures, as described earlier, should be counted as benefits.

CONCERN WITH ARMS

We talked with a number of individuals who had cogent critiques of ARMS.

One class of criticism is that having tenants at plants increases plants' costs. Hence, "avoided expenditures" are overstated.

We tend to accept OSC's views on this matter, however. Many plant costs are fixed. Water costs, sewer costs, fire protection costs, and security costs all figure to be approximately static with or without tenants. Tenants are metered and charged separately for electrical usage. We do not believe Table A.5's net benefits are grossly overstated due to tenant-driven cost increases, though we would agree Table A.5's numbers are probably more likely to be overestimates than underestimates (as is also true of Table A.4, because of the issue of environmental expenditures).

Another critique of ARMS is that the program makes a facility contractor play a role it is not qualified for. Specifically, most facility contractors are munitions producers. Attracting and luring good tenants requires a skill set more traditionally associated with a commercial real estate broker. As noted in Table A.1, however, Section 194 of the ARMS Act assumes that the

facility contractor attracting tenants is also the firm responsible for ammunition manufacturing.

We think this criticism is a valid one. We would encourage steps to separate the munitions production role from the commercial broker role, including, if needed, a legislative change. While the current arrangement offers the advantage of simplicity in that it requires only a single contract, on the net we see no overriding reason why the firm responsible for fulfilling a plant's ammunition mission should be attempting to attract tenants, although a production contractor could subcontract the function.³³ Nonetheless, real estate marketing is not generally a core competency of ammunition manufacturers.

Another criticism of ARMS is that it may postpone or hinder efforts to remove a plant from Army ownership. In particular, if the Army postpones its declaration of a plant as excess solely to continue to benefit from ARMS considerations, it opens itself to ethical questions.

We have heard different views on this topic. One argument is that, even if a plant is declared excess, the Army will likely own it for years while required environmental remediation takes place. This is currently what is occurring at Indiana and Volunteer, for instance. Walton (2000a, 2000b) discusses Volunteer's cleanup challenges. Under this scenario, having tenants at the plant during this transition can be helpful on two levels. First, tenant payments reduce the amount the Army must pay for basic operation (e.g., keep the property secure). Second, the plant's tenants can serve as segues into the non-Army future that awaits the plant, thereby benefiting the excessed plant's community.

An alternative view, however, is that the Army could accelerate its process of disposing of property. For instance, one might imagine a plant being turned over to a new operator concurrent with Army-funded cleanup of the plant. The report of the Rapid Improvement Team Breakthrough Engagement (2000) discusses such a potential reform. The legalities of an expedited transfer process are discussed in 1996 amendments to Section 120(h) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC Section 9620[h]). As mentioned above, the Army's experience with this authority has been less than successful. It is not clear, however, whether an improved process to implement this statutory authority might be made to work.

³³In at least one plant we visited, the facility contractor had hired a professional real estate developer to plan and market the plants.

If disposal were expedited, having existing ARMS tenants with long-term leases could change from being an advantage to being an encumbrance.

It is hard to judge the merits of this argument in that no plant rendered excess to date has followed this alternative approach.

Another critique of ARMS is that the program could have been more cost-effective if facility contractors had invested more of their own funds.

To get facility contractors to invest more of their own money, one would probably have wanted a different type of contractor, e.g., a commercial real estate developer, in accord with the criticism above. This different facility contractor would also need a long-term contract, which would increase the concern that one would be constraining future Army decisions to close or render the plant excess.

OSC personnel noted facility contractor reluctance to invest their own money and a difficulty borrowing money when the contractor does not own the plant. Of course, Army funding could have, alternatively, been used in a loan guarantee program to assist facility contractor efforts to borrow funds. Indeed, the FY01 Defense Authorization Act includes provision for an ARMS loan guarantee program.

As with the accelerated disposal argument, it is hard to compare what actually happened with a substantially different program that was not implemented.

A final concern about ARMS is that it has the appearance of subverting congressional intention. As an alternative to ARMS, Congress could simply appropriate more money for such uses as buying ammunition, plant upgrades and cleaning, and MIIF. It has not done so, instead choosing to appropriate roughly \$20 million per year to ARMS. As noted, however, ARMS's ultimate benefits to the Army lie in the form of cheaper ammunition, upgraded ammunition plants, and lower MIIF expenditures.

OSC has not been secretive about ARMS's benefits, so one cannot readily label this outcome to be furtive.

THE FUTURE OF ARMS

We have concluded, despite the data issues mentioned above that apparently overstate both ARMS's net costs and net benefits, that the ARMS program has achieved three of the program's aims. In particular, it

- encouraged commercial firms to use GOCO facilities;

- increased the opportunities for small businesses to use such facilities; and
- contributed to economic stability.

The extent to which the program has achieved the other stated aims is less clear. Further, the need to retain all the plants engaged in ARMS is in doubt.

One can criticize ARMS's structure (e.g., having munitions producers attempting commercial development), but we do not see serious problems with how OSC has operated this program.

The successes of ARMS notwithstanding, we wonder whether the ARMS program will peter out over time, at least at ammunition plants.

OSC data suggest that fewer plants will receive MIIF, with Holston, Kansas, Lake City, Mississippi, and Scranton all projected to receive no MIIF in 2003. Once zero MIIF is achieved at a plant, one of the most pressing motivators for ARMS would seem to be eliminated (though ARMS-derived tenant revenue could be used to fund environmental cleanup projects or other considerations).

We also wonder whether some plants are simply in undesirable locations or have sufficiently obsolete facilities that the number of profitable ARMS expenditures that can be made at these sites is limited. The best opportunities for tenants may already have been addressed.

ARMS seems incompatible with an evolving policy of setting up long-term, fixed-price production contracts with plant operators like Alliant at Lake City. An ARMS expenditure under such a regime improves operations for the contractor but would not redound to the government's favor if a long-term, fixed-price production contract is in place. OSC is obviously cognizant of this reality.

A broad alternative to the ARMS program may reside in the authority of 10 USC 2667, which provides for leasing real or personal property. TACOM-ARDEC (Armament Research Development and Engineering Center) is using this authority to seek a private developer to participate in the development of real estate assets at Picatinny Arsenal. This approach, if successful, would offer the advantage of having a real estate professional rather than an ammunition manufacturing firm manage the development. Further, the program would generate actual revenue dollars for the government rather than the in-kind considerations of the ARMS program. Under 10 USC 2667, lease revenue would be deposited in a special Army

account. Half of such revenue would be available to the installation for facility maintenance and repair; the other half would be used Army-wide for the same purpose. This program offers a third benefit relative to ARMS: It requires no appropriated investment funds.

APPENDIX B—REQUIREMENTS, CAPACITIES, AND MARKETS

Requirements, Capacities, and Markets

- **Market context**
 - U.S. policy for the organic industrial base
 - Broader market
- **Identify key products**
- **Private-sector market penetration and interest**
- **Requirements for the product**
 - Peacetime
 - Replenishment
- **Economy of production**
- **Identify production options**

This analysis will continue as required by the sponsor throughout the project

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This appendix compares the Army's requirements to manufacture or purchase ordnance materiel with the capacities to produce such materiel. Those capacities reside in the organic base, in the U.S. private sector, and overseas. U.S. policies determine the extent to which the Army may rely on external sources, either in the United States or overseas. Further, the current policy directs the services to consider overseas capacities in their replenishment planning.³⁴ As documented above, the general policies of the United States are to rely on the private sector to the maximum extent possible. Exceptions are considered in the face of overriding national security considerations, market failures, or for other economic reasons.

The data provided below shed light on the extent of government-owned, private U.S., and overseas capacities and place the magnitude of existing Army requirements for such materiel in light of these capacities.

³⁴As of April 2000.

Both the programmed and replenishment requirements are juxtaposed with organic, private U.S. and overseas capacities. Real and potential private-sector interest is noted to identify production options.

To the extent that the Army requires it, this analysis will continue through Phase 3 of this study. Because of the early Phase 1 focus on the arsenals and the nature of the items produced by them, the analysis for the ordnance items manufactured at Rock Island and Watervliet is fairly straightforward and is nearly complete; the analysis for ammunition items is much more complex and is treated in less depth. For the purposes of this report, it need only assist in the formulation of options for the organic industrial base. The level of detail required for analysis of specific options within Phase 3, therefore, may be greater than that presented here.

Identifying Key Products

- Watervliet Arsenal (WVA)—large-caliber cannons
- Rock Island Arsenal (RIA)—towed artillery (minus the gun tube) and gun mounts
- Ammunition Production Facilities
 - Explosives
 - Propellants
 - Small caliber
 - Medium caliber
 - Metal Parts
 - LAP
 - Specialty components

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We define the key products of the Army's organic industrial base as those that are traditionally argued to justify the existence of particular facilities within the base. The definition of key products is imprecise but tends to mean products that organic facilities have substantial expertise to manufacture. We do not adhere to the notion that the existence of such products necessarily justifies the retention of an organic base to manufacture them. Even unique capabilities can be privatized. Indeed, Newport News Shipbuilding and Drydock Company, the sole U.S. facility to build aircraft carriers, is private. To be sure, so long as that capability is needed, the government must ensure its continued existence, just as it must with unique capabilities in the organic base. But unique capabilities do not need to be owned by the government solely because of their uniqueness.

Nevertheless, key products provide strong, if not always persuasive, arguments for the continued existence of organic facilities. In that spirit, we identify these products and elaborate on the requirements for them.

For Watervliet Arsenal (WVA), the key product is large-caliber cannon systems. Cannon systems are made up of the gun tube, breech mechanism, and muzzle brake or bore evacuator.

Rock Island Arsenal's key products are gun mounts and towed artillery systems. Gun mounts include recoil mechanisms and the hardware

associated with installing large-caliber cannon onto combat vehicles. The manufacture of entire towed artillery systems requires expertise similar to that required to build gun mounts.

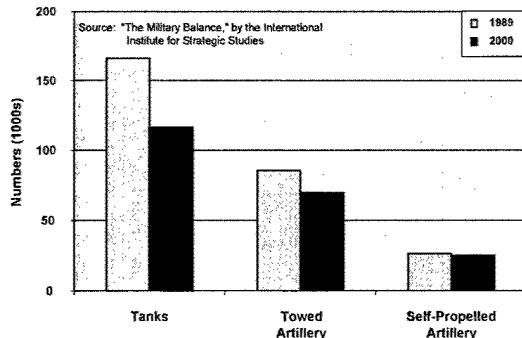
The organic ammunition industrial base is much more varied than the two ordnance arsenals. Holston Army Ammunition Plant (AAP) is the primary producer of military explosives in North America. Radford AAP produces various gun and rocket propellants. It also maintains lines for the production of TNT. Lake City AAP's key products are small-caliber ammunition. Scranton, Riverbank, Mississippi, and Louisiana AAPs are responsible for various ammunition metal parts components. Lone Star, Iowa, Milan, Kansas, and McAlester load, assemble, and pack (LAP) finished ammunition as their principal purpose. Finally, specialty items, such as smoke, white phosphorus, and illumination ammunition form a key product group for Crane Army Ammunition Activity (AAA) and Pine Bluff Arsenal.

The above itemization of the ammunition facilities is not meant to be exhaustive. Several of the listed ammunition facilities have multiple ammunition missions and core products, but in general, the key ammunition products are identified.

As mentioned in the body of this report, the organic ammunition base conducts only a minority of the total ammunition manufacturing effort. Far more production, particularly of components, occurs in the contractor-owned, contractor-operated plants of 67 private manufacturers.

Market for Conventional Ordnance Items

Worldwide Inventory of Weapons



- Many nations are buying excess inventory, rather than buying new
- NATO tank production has declined from >1,000/year to ~200/year
- The worldwide market for self-propelled artillery is stagnant
 - Most new production has been for the Koreas (1,000 for S. Korea and 2,000 for N. Korea)
 - General modernization in the Mideast, but this is winding down

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Our analysis of WVA's and Rock Island's key products (cannon, gun mounts, and towed artillery) begins by looking globally. Since the end of the Cold War, demand for defense products has declined or stagnated. Obviously, the fall of the Berlin Wall and the demise of the Warsaw Pact dampened demand in Europe for major purchases of ground combat systems. The worldwide effect was even larger, however. Without superpower sponsorship, other regions of the world, notably the Middle East, could no longer afford to continue buying arms at the same level. As a result, the worldwide inventory of systems with large-caliber cannon has declined markedly over the last decade.

If weapons were being replaced by newer systems, the decline in these inventories would not necessarily affect the industrial base that makes them. That is not the case, however. Instead, older systems are being retained in frontline service and are merely being upgraded. Additionally, the surfeit of older systems that results from declining inventories is being sold to nations that might otherwise buy new. The net result is that the number of cannon, gun mounts, and towed artillery systems being produced each year have declined dramatically. Countries buying new systems are doing so in much smaller numbers over an extended period of time.

Tank production is a good example. NATO tank production is down from more than 1,000 new systems per year to less than 200 per year; even when upgrades are included. Focusing on the United States, one finds the upgrade of M1 tanks to M1A2 standard proceeding at only 120 per year, with pending program completion. A new Mobile Gun System (MGS) with a 105-mm cannon will be produced for the Army's medium-weight brigades, but only about 200 are to be produced over the next eight years. Its successor, the Future Combat System, is anticipated in about 2010 or later, but it is not known if it will even mount a cannon.

The situation is similar for artillery systems. Global production is down considerably. Even regions that did purchase new systems in the 1990s (the Koreas and in the Middle East) appear to be nearing the end of their artillery modernization drive. The Koreas increased their inventories of self-propelled artillery by several thousand over the last decade in a process nearing completion. Likewise, in the Middle East several countries modernized their artillery arms in a general mechanization drive, but like the Koreas, that process is also nearly finished.³⁵

³⁵Data derived from *The Military Balance 1999–2000*, London: Oxford University Press for the International Institute for Strategic Studies (IISS), 1999, and from *The Military Balance 1988–1989*, London: IISS, 1988. Some information also gleaned from several volumes of Christopher F. Foss, *Jane's Armour and Artillery*, London: Jane's, 1999.

Private Sector Can Produce Large-Caliber Cannon

- **Private-sector market for cannon production**
 - Current private-sector production
 - Naval systems
 - Foreign systems
 - Private-sector interest in Watervliet Arsenal
- **No national security requirement that requires government production**
 - Ratio of peacetime to replenishment requirements is small
 - No underlying security issue
- **Private sector can produce cannon economically**

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An analysis of cannon production indicates that there is neither a market failure nor an overriding national security concern that would dictate cannon production on a government installation by government employees.

The U.S. Navy transferred its cannon production to United Defense in the mid-1990s, indicating a market willingness to produce cannon.

Additionally, a number of foreign companies also produce cannon for their own domestic and international markets. As a final check on the market attractiveness, last year a consortium of three defense companies expressed interest in producing cannon for the U.S. government at WVA.

Likewise, national security concerns do not require that cannon be produced at a government arsenal. Replenishment requirements for cannon are relatively modest. A large reserve of capacity requiring government ownership to guarantee availability is not required. Also, the technology required to make cannon, while specialized, is not secret. No underlying information security concerns therefore would require government ownership and control of production assets.³⁶

³⁶The Stratton Amendment (10 USC 4542) does restrict the transfer to a foreign country of technical data packages related to the manufacture of large-caliber cannon, but the measure does not pertain to security of classified information.

Finally, the Navy and overseas producers of cannon have demonstrated that private companies can produce large-caliber cannon at acceptable cost.

The bottom line is that the private sector can produce large-caliber cannon. None of the exceptions to the national policy that favors private over public production of defense goods applies. Starting with a brief description of the processes involved in cannon production, these exceptions will be discussed in greater detail through the next few figures.

WVA Is Integrated to Conduct All Necessary Operations

- Forging of rough tubes
- Heat treating of metal
- Deep hole drilling and boring
- Rough and finish machining of gun grade steel
- Auto-frettage
- Rifling
- Chrome-plating
- Straightening
- Inspection

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The following lists the processes necessary for the production of high-quality, modern, large-caliber cannon:³⁷

- forging of rough tubes
- heat treating of metal
- deep hole drilling and boring
- rough and finish machining of gun grade steel
- auto-frettage
- rifling
- chrome-plating
- straightening
- inspection

³⁷This list is derived from the author's experience and through Roger Billington, engineer in Office of the Program Manager, Crusader, personal communication, May 18, 2000.

Some of these processes are unique to cannon production, but none is unique to WVA. WVA lists the following critical processes as unavailable in industry: guided boring, rifling system, midwall cooling, heat shrink, swage overstraining, bore coating technologies, and multilug breech. In some cases, the distinction between what exists at WVA and in the private sector is a matter of degree. What is clearly unique is WVA's vertical integration of all these processes into one facility that starts with a rough billet of steel and finishes with a complete cannon system.

No Market Failure for Cannon Production

- **United Defense (Louisville)—Bid on LW155 program**
 - Making the Naval 5-inch and 3-inch guns (20 to 30 per year, at 20% capacity)
 - Facilitating for Navy's 52-caliber, 155-mm gun (AGS)
 - Vertically integrate for all but forging operations
 - UDLP estimates that facilitization for the Navy's AGS also facilitates for LW155 production
 - Army experts question UDLP ability to make Army cannon
 - Knowledge, processes, and equipment
 - Facilitation cost—up to \$35 million
 - Learning curve estimated at 18 to 24 months
 - Private industry expert (Battelle) considers UDLP production quite possible
- **Forging Facilities (National Forge, Wyman-Gordon, Scott Forge, IRI)**
 - National Forge provides raw materials (preforms) and near net shape forgings (tubes) to Watervliet and UDLP
 - None of these facilities are vertically integrated to make cannon
 - Chrome-plating, rifling, swage auto-frettage, finish machining
 - Government estimates to facilitate National Forge—\$50 million

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The first exception to the national policy that favors using the private sector for production of defense goods applies when there is a market failure for specific items. Examination of the market for large-caliber cannon indicates that there is no such market failure. Alternative sources of supply, both domestic and international, exist or could be developed.

As mentioned earlier, the Navy transferred its cannon production capability to the private sector a number of years ago. Prior to the transfer, the Department of the Navy owned and ran a facility in Louisville, Ky. Today that real estate is owned by the city of Louisville and rented to United Defense Limited Partnership (UDLP), which continues to make cannon for the Navy there. The Louisville cannon factory is operating at only 20 percent capacity, but UDLP is facilitating it to make the Navy's Advanced Gun System (AGS): a 52-caliber, 155-mm cannon. Once the facilitization is complete, UDLP will be vertically integrated for all cannon production processes, except forging, which it will continue to contract out. The combination of excess capacity and ongoing vertical integration allowed UDLP to respond affirmatively to a request for competition information concerning the LW155-mm howitzer. UDLP estimates that little, if any, additional facilitization cost beyond that associated with the AGS

facilitization, already budgeted for by UDLP and the Navy, would be required in order to manufacture the LW155.³⁸

This estimate may be optimistic. Army experts from Benet Laboratory and PMs Crusader and LW155 believe the cost to facilitate will be substantially higher (as high as \$35 million). Additionally, these experts expressed the opinion that UDLP, though competent at making naval cannon, did not understand the manufacturing requirements for Army howitzers and that it would take approximately 18 to 24 months to learn the nuances associated with making these systems. They also believe that some of the equipment UDLP planned to use would not be suitable for the LW155 application. Overall the Army's experts stated that production of the LW155 at Louisville would be a high-risk endeavor.³⁹

Countering the Army assessment, a cannon manufacturing expert from Battelle believes that learning-curve issues could be overcome and that UDLP could successfully manufacture the LW155. Though he cited neither specific facilitization costs nor learning-curve estimates, he did express the opinion that the Army estimates were too pessimistic.⁴⁰

In addition to the dedicated cannon-making facility in Louisville, a number of large forges in the United States could, and do, participate in some stages of large-caliber cannon production. National Forge in particular is an interesting example. This company in northwest Pennsylvania provides near-net-shape gun tube forgings to UDLP's Louisville facility and has, in the past, provided them to WVA.⁴¹ Near-net-shape gun tube forgings are essentially roughed-out cannon. In addition to this forging capability, National Forge can accomplish rough machining and hydraulic auto-

³⁸Medley, Linda, "Cannon Capability Briefing to Colonel Steve Ward," Louisville, Ky., October 21, 1999. Some information provided during a site visit to UDLP's Louisville facility. Interview and tour with Michael Santoro on June 28, 2000; private communication, January 11, 2001.

³⁹Hasenbein, Richard G., Associate Director, Design & Development, Benet Laboratories, undated memoranda, "Qualitative Assessment After Site Visits LW155 Cannon Cost IPT"; and Timothy J. O'Connor, Benet Laboratories, undated memoranda, "Site Visit—UDLP Louisville XM776 LW Cannon Manufacturability of Components"; Roger Billington, memorandum, "Technical Evaluation of Alternate Sources to Manufacture the Light Weight XM776 Howitzer for the Joint Program Manager Light Weight 155mm," April 3, 2000; Michael D. Della Terza, personal communication, May 19, 2000; and Roger Billington, personal communication, May 18, 2000.

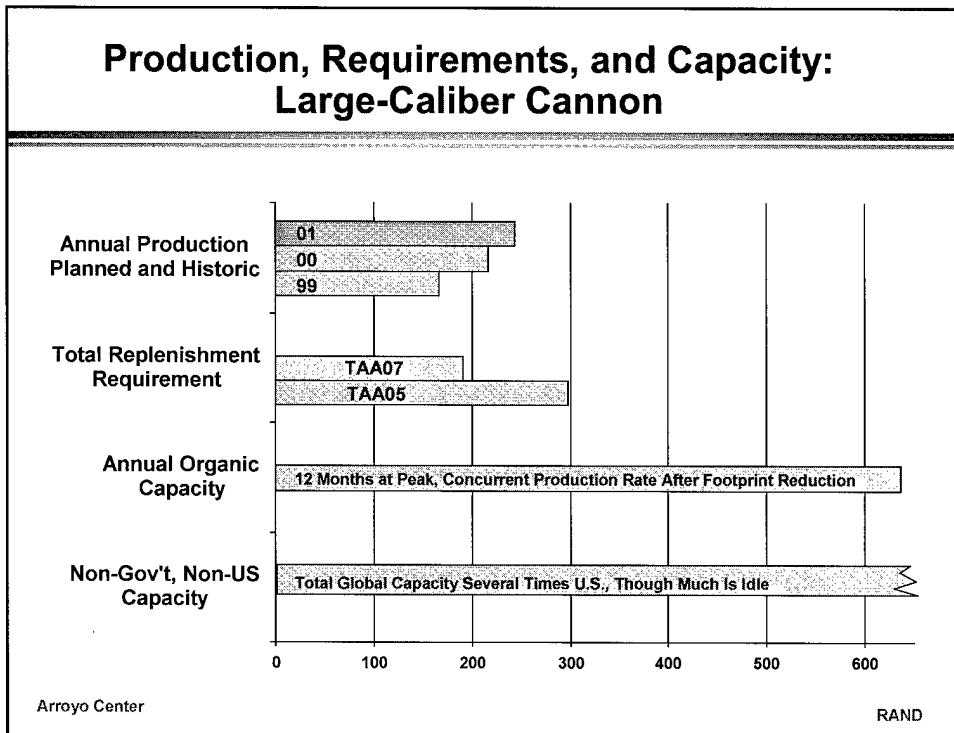
⁴⁰Wildman, James E., personal communications, summer 2000.

⁴¹Ruhlman, James, and Don McNeal, personal communications during interviews and a tour of the National Forge facilities, June 29, 2000.

frettage of the forgings. Government cannon experts estimate that the cost to fully facilitate National Forge for the vertically integrated production of cannon is approximately \$50 million.⁴² There are other options, however. These include contracting out some of the services needed to finish the cannon. For example, chrome-plating and fine machining could be accomplished elsewhere. While this may sound inconvenient, many companies forgo vertical integration and contract out those processes that can be accomplished more economically through outsourcing. European cannon manufacturers, to be discussed in more detail later, have taken this approach.

The second exception to the national policy that favors using the private sector for production of defense goods applies when there is a national security reason for maintaining government ownership and control with regard to specific defense items. This may apply when the technology required to develop and produce the item is too sensitive to trust with the private sector. This is clearly not the case for large-caliber cannon. While specialized and even proprietary in some cases, the technology behind the development and production of cannon is unclassified. The second exception may also apply when there is a need to maintain a very large production capability compared to that required for normal peacetime production; such is not the case for cannon production.

⁴²Strong, Frank, Program Executive Office for Ground Combat Support Systems, memorandum, "Trip Report to National Forge Company @ Irvine, PA and UDLR @ Louisville, Ky.," September 1, 1999, and Roger Billington, personal communication, May 18, 2000.



This figure compares recent and current production levels of large-caliber cannon at Watervliet with replenishment requirements as stated by the two most recent Total Army Analyses (TAAs), with WVA's capacity on a one-shift basis, and with global capacities. (Appendix C contains a description and assessment of the TAA process.) Recent and current production of large caliber cannon at WVA for domestic purposes averages just over 100 per year, and production quantities for foreign sales are similar. In addition, 100 to 200 mortar tubes are produced each year, but these require much less work. This production is currently accomplished on a one-shift basis.⁴³ Using the last two TAAs as a basis, the total replenishment requirement is somewhere between 190 and 300 large-caliber cannon. On a three-year replenishment cycle, the Army needs capacity to produce 100 cannon or fewer per year plus continued programmed production of about 200 a year. Even if one factors in additional production to account for increased wear during combat use, it appears that any replenishment requirement could be easily met with existing capacity. In fact, WVA's capacity on a single shift will remain at least twice the replenishment rate (after the current "footprint" reduction efforts are completed, WVA will

⁴³Data provided by WVA personnel.

have a single-shift capacity greater than 600 cannon per year).⁴⁴ That replenishment production rates appear quite manageable indicates little need for the government to maintain idle capacity that could be rapidly brought on line during a national emergency.

⁴⁴LaDue, Gary, electronic communication, September 21, 2000. Cannon production capacity will be 53 per month once the footprint reduction is complete. Capacity before the start of the reduction was 110 cannon per month.

Cost of Production Does Not Justify Government Ownership/Operation of WVA

- Request for information (RFI) identified three potential sources for LW155 cannon production (Watervliet Arsenal; UDLV Louisville; Watervliet International)
 - Estimated costs were roughly comparable
 - WVA costs highly sensitive to quantity and schedule
 - Private source sensitivity to quantity and schedule not currently evaluated
- Rheinmetall offered developmental “long” 120-mm tank cannon at or below the Watervliet cost

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The third exception to a policy that relies on the private sector for defense production occurs when the government already owns the means of production for an item and could produce the item more economically than the private sector. This exception is based on the Arsenal Act (10 USC 4532).

There have been no direct competitions for cannon production in the United States for decades, if ever. This makes it difficult to find direct cost comparisons, but some information is available. From this limited information it is possible to make inferences as to whether the cannon production is likely to fall into the cost exception.

Over the course of the last year the Department of the Navy decided on an acquisition strategy for the lightweight 155-mm howitzer (LW155). This program, run by a Marine Corps PM, identified two competitors to WVA willing to produce the cannon for the LW155. These were UDLV, identified earlier, and Watervliet International (WVI)—a consortium of General Dynamics Land Systems (GDLS), British Aerospace (BAE), and UDLV. WVI has an interesting history: The three companies with the greatest stake in American cannon production formed the consortium that comprised WVI.

The consortium then made an unsolicited offer to run WVA as a GOCO facility.⁴⁵

The PM ultimately chose WVA to produce his cannon, but during the course of his decision process asked each of the potential producers to provide cost estimates for producing the LW155 cannon. Two caveats are important concerning the estimates ultimately provided. First, these were, in fact, just estimates. No Request for Proposal (RFP) was issued, so the cost data provided were most likely subject to substantial adjustment were the competitors actually making offers. Second, the cost data were issued for only one scenario of production: 450 cannon for the Marine Corps, 273 cannon for the Army, with Marine Corps production over three years starting in FY03. Based on this scenario, the PM determined that WVA provided the best combination of cost and risk. Under this scenario, WVA cost per cannon was roughly 10 percent lower than UDLR cost. Uncertainty made WVI cost estimates difficult for the PM to assess, but they appear comparable or more expensive than WVA, depending on assumptions.⁴⁶

Since the PM made the initial cost estimates, however, the assumptions concerning the numbers of systems to be bought and the schedule under which they will be produced have changed significantly. First, the production schedule for the Marine Corps buy was extended from three to four years. This caused a 10 percent increase in WVA's per-cannon cost. Next, the Marine Corps quantity decreased to just more than 400 and the start of production was bumped into the next fiscal year. These changes caused an additional 25 percent increase to the cost of each cannon. While it is likely that some action (for example, providing Army funds to move production back to the original start date) will alleviate these cost increases, cannon cost at WVA appears to be highly sensitive to production quantity and schedule.⁴⁷

While WVA's competitors did not fully assess their costs for the new production scenarios, both reiterated their initial per-cannon cost estimate to RAND during interviews that occurred after the initial change to a four-

⁴⁵Briefing to Assistant Secretary of the Army, "Watervliet International LLC," June 14, 2000.

⁴⁶Wilson, Alan, briefing to Assistant Secretary of the Army (P. Hoeper) and Assistant Secretary of the Navy (L. Buchanan) "PM's Analysis on LW155 Cannon Costs: Watervliet versus Louisville," May 5, 2000.

⁴⁷Wilson, Alan, U.S. Army Operations Support Command, personal communication, October 12, 2000, and James Shields, Deputy Program Manager, Joint Lightweight 155 Program, personal communication, October 17, 2000.

year production schedule for the Marine Corps cannon.⁴⁸ It is likely that both UDLP's and WVI's per-cannon cost are somewhat less sensitive to quantity and schedule than WVA's. This is due to the flexibility afforded private contractors compared to a government arsenal. For example, UDLP's current workforce is sized to its current production requirements for the Navy. Were it to receive a contract to produce LW155 cannon, it would hire only enough new employees on a schedule that supported the new production. WVA, on the other hand, has much less flexibility. In the short run, its workforce size is only partially dependent on the workload at the arsenal. This is especially true when it comes to reducing workforce during times of lean production. Government rules concerning reductions in force create expensive delays in sizing workforces. Combined with government financial regulations that require customers to bear all costs at the arsenal, this lack of flexibility results in product costs that are very sensitive to production quantity and schedule.

The bottom line therefore seems to be that the per-cannon cost between the three potential suppliers appears to be roughly comparable.

One other piece of information indicates that government ownership and operation of WVA does not necessarily confer an advantage in the cost of large-caliber cannon. The PM for Tank Main Armament Systems has requirements for research and development (R&D) quantities of a new tank cannon. As with the LW155, no official solicitation for these items was issued but discussions between the PM and Rheinmetall, the German company that developed the new cannon, indicated that Rheinmetall would be able to fill the requirement at or below the WVA cost.⁴⁹ This information should not, of course, be considered definitive, only indicative.

⁴⁸Fitzpatrick, Tom, United Defense LP representing Watervliet International during discussions at RAND's Arlington, Va., offices, July 12, 2000, and Michael Santoro, United Defense LP during meetings and a plant tour at Louisville, Ky., June 28, 2000.

⁴⁹Gaudet, Robert, Rheintech, Inc., representing Rheinmetall during discussions at Rheintech in McLean, Va., June 2, 2000, indicated that Rheinmetall could provide R&D tank cannon for less than WVA cost; and Morris, Robert, et al., Program Manager for Tank Main Armament Systems during discussions at Picatinny Arsenal, N.J., May 19, 2000, would not provide actual cost comparison between WVA and Rheinmetall for R&D tank cannon but noted that costs were comparable.

Private Sector Can Produce Towed Artillery and Gun Mounts

- Private-sector market for towed artillery and gun mounts production
 - Current private-sector production
 - Private-sector interest in LW155 production
 - Rock Island Arsenal only current producer of hydropneumatic recoil
- No national security requirement that requires government production
 - Ratio of peacetime to replenishment requirements is small
 - No underlying security issue
- Private sector can produce towed artillery and gun mounts economically

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An analysis of gun mount and towed artillery production indicates that there is neither a market failure nor an overriding national security concern that would dictate gun mount and towed artillery production on a government installation by government employees.

That General Dynamics produces half the gun mounts for the M1A2 tank is indicative of market willingness to produce these items. Additionally, foreign companies will be producing gun mounts for two major U.S. Army programs—the Interim Armored Vehicle (IAV) and the LW155. Final assembly of the complete LW155 towed artillery system will be done by UDLP rather than by RIA. RIA's role in this system is limited to producing the ammunition load tray. That RIA will produce very few of the Army's new gun mounts and is only peripherally involved in production of new towed artillery for the Army makes it clear that there has been no market failure with regard to gun mounts and towed artillery.

Likewise, national security concerns do not require that gun mount and towed artillery be produced at a government arsenal. Replenishment requirements for these items are relatively modest. A large reserve of capacity requiring government ownership to guarantee availability is not required. The technology required to make gun mounts and towed artillery, like cannon, is reasonably specialized but is not secret. There are

therefore no underlying information security concerns that would require government ownership and control of production assets.

Finally, that program managers have decided to use private companies to produce the gun mount and towed artillery systems charged to their care demonstrates that the private sector can produce these items economically.

Rock Island Arsenal Is Integrated to Conduct All Necessary Operations

- Casting and forging operations
- Metal bending, cutting, and shaping
- Finish machining
 - Very high tolerances
 - Large pieces
- Plating
- Welding
 - Various processes
 - Various materials
- Assembly
- Inspection

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The following list of processes is necessary for the production of high-quality, modern gun mounts and towed artillery:⁵⁰

- casting and forging operations
- metal bending, cutting, and shaping
- finish machining
 - very high tolerances
 - large pieces
- plating
- welding
 - various processes
 - various materials
- assembly
- inspection.

⁵⁰This list is derived from the authors' experience and conversations with Rock Island Arsenal personnel.

None of these processes are unique to gun mounts and towed artillery production. What is unique is RIA's vertical integration of all these processes into one large facility. This provides some degree of responsiveness in emergency situations, though the responsiveness is acquired at the cost of maintaining significant underutilized capacity.

No Market Failure for the Production of Gun Mounts and Towed Artillery

- Most processes conducted at RIA are not unique and a number of manufacturers have claimed an ability to do aspects of the work.
- General Dynamics splits M1A2 gun mount production between Rock Island Arsenal and its Muskegon, Mich., facility—both have capacity to do all production
- UDLP produces gun mounts for naval applications
 - Very low volume
 - Developing next-generation naval gun system (52-caliber, 155-mm)
- In response to BAE solicitation, there were 38 bidders for items on the LW155 normally produced by RIA

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Officials at RIA often note that RIA is the only *proven* American producer of hydropneumatic recoil systems as used on fielded American artillery systems. This statement, while true so far as Army systems go, means less than intended. Hydropneumatic recoil systems are standard artillery recoil systems, introduced over a century ago by the French⁵¹ and now produced by nearly every country that manufactures artillery.⁵² RIA is the only proven U.S. maker of these recoil systems because it has been the only producer of U.S. artillery hydropneumatic recoil systems. As noted on the previous figure, however, none of the processes used to make gun mounts, towed artillery, and the recoil units integral to them are unique to RIA. These standard industrial processes are required to manufacture everything from automobiles to zeppelins. While some aspects, such as close tolerance machining of large metal items, may be specialized, companies both in the United States and abroad are capable of the work.

Indeed, a number of private companies have expressed both a willingness and demonstrated the capability to manufacture gun mounts and towed

⁵¹“Artillery, Recoil Control,” *Encyclopedia Britannica*, <http://www.britannica.com/bcom/eb/article/4/0,5716,118834+4+110176,00.html>.

⁵²Foss, Christopher F., *Jane's Armour and Artillery*, London: Jane's. Volumes since 1990 used.

artillery pieces. Though RIA has been the only producer of artillery mounts and recoil systems in the United States for a number of years, it produces only half of the Abrams tank gun mounts (hydro-spring recoil), with GDLS producing the rest in Muskegon, Michigan. Importantly, GDLS or RIA could have easily managed production of the entire annual requirement had the program manager so decided.

UDLP produces gun mounts and the associated recoil mechanism for the U.S. Navy and will assemble the towed LW155 artillery piece. The Mk. 45 five-inch naval gun system produced by UDLP uses a hydropneumatic system. These systems are produced in very low quantities but are nevertheless produced and could presumably be produced in larger numbers if the market grows. Additionally, UDLP is developing and will produce the next-generation naval gun system, the Advanced Gun System, a 52-caliber, 155-mm cannon, similar in size to Army artillery systems.⁵³

Perhaps most telling, neither the recoil system for the LW155 towed artillery piece nor final assembly of finished product will be done at RIA.⁵⁴ The prime contractor for the LW155, BAE, issued a solicitation to produce components of the system and for final assembly of the system. Thirty-eight responsive bids were received from both private contractors and government manufacturing concerns.⁵⁵ As mentioned, UDLP won the competition for final assembly and BAE retained production of the recoil mechanism.

Even more recently, the decision concerning IAV production was announced. A team of General Motors (Canada) and GDLS won the competition. Significantly, the gun mount for the 105-mm tank cannon to be mounted on the associated MGS will be produced in Israel, rather than at RIA.⁵⁶ The decision to go offshore is of particular note since General Dynamics has its own domestic capability. As mentioned previously, General Dynamics makes Abrams gun mounts in the United States.

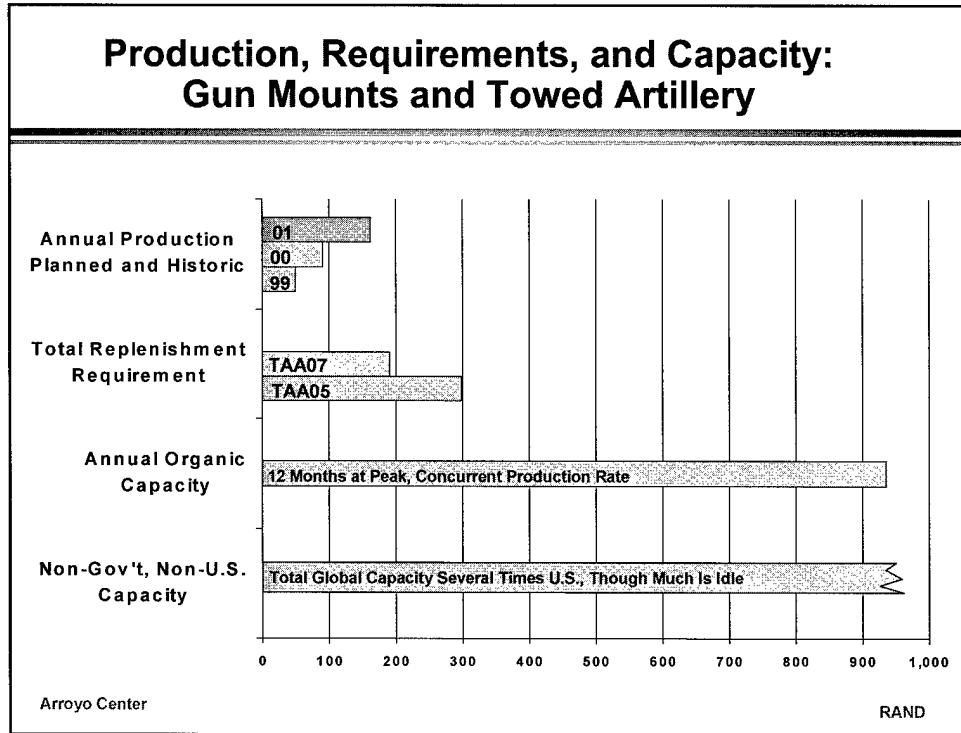
⁵³The UDLP Web site lists its product line: <http://www.udlp.com/markets/index.html>.

⁵⁴Strohem, Chris, "Contractor For LW155 Selects U.S. Partners, Readies for Production," *Inside the Army*, Vol. 12, No. 38, September 25, 2000.

⁵⁵Mullins, Thomas (Office of the Assistant Secretary of the Army for Acquisition, Logistics and Technology), in telephonic conversation with John Bondanella (RAND), May 31, 2000.

⁵⁶Kern, Lt. Gen. Paul J., DoD News Briefing, November 17, 2000, http://www.defenselink.mil/news/Nov2000/t11172000_t117army.html presented with the briefing chart "IAV Prime and Subcontractor Locations," <http://www.defenselink.mil/news/Nov2000/001117-D-0000C-003.jpg>.

All of the above suggests that there is no market failure in terms of gun mount and towed artillery production. Domestic and international producers remain willing to produce these items and appear to have wrested most of the market from RIA.



The second exception to the national policy that favors using the private sector for production of defense goods—national security reasons—is clearly not relevant for gun mounts and towed artillery. While specialized, the technology behind the development and production of gun mounts and towed artillery is not particularly sensitive.

This exception may also apply when there is a need to maintain a very large production capability compared to that required for normal peacetime production, but such is not the case for these items. Recent and current production of gun mounts and towed artillery at RIA runs between 50 and 100 per year.⁵⁷ Yet their one-shift capacity is about 500 per year. This production is currently accomplished on a one-shift basis. The total replenishment requirement is approximately 190 to 300 gun mounts and towed artillery pieces. Hence, on a three-year replenishment cycle, production of these items needs to increase by 100 or less per year.⁵⁸ This appears to be reasonable and should be easily met with current capacity of

⁵⁷Figures relate to last few years of production near-term projections and are based on data provided by Rock Island Arsenal personnel.

⁵⁸These figures are derived from the TAA05 and TAA07.

500 per year.⁵⁹ That replenishment production rates appear quite manageable indicates little need for the government to maintain idle capacity elsewhere that could be rapidly brought on line during a national emergency.

OSC personnel have argued that cannon and gun mounts should continue to be made by government employees because it would take longer than three years to reestablish a skill base and equipment required for replenishment. This argument misses the point that under any of the options considered in this study, a workforce will continue to manufacture the items required in peacetime, thus keeping their manufacturing skills sharp. It also ignores the advantage that either a privatized capability or an FGC offers—namely, the potential for increased manufacturing workload that would provide for an even more capable workforce.

⁵⁹The current capacity figure of 500 gun mounts and towed artillery pieces per year was estimated by comparing historical production with equipment availability and workforce size.

Cost of Gun Mount and Towed Artillery Production

- Legacy howitzer gun mounts and towed artillery produced only at RIA, so no good comparisons
- BAE elected to retain LW155 recoil system production indicating no overwhelming economic advantage to RIA production of these items
- GDLS Abrams 120-mm gun mounts production is split between GDLS facility and RIA—studies suggest GDLS long-term costs may be lower

No reason to think that RIA can produce gun mounts or towed artillery at significant savings over private-sector company

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Because U.S. howitzer gun mounts/recoil systems have previously been produced solely at RIA, it is difficult to make cost comparisons for these systems. Recently, however, BAE solicited production of portions of the LW155 towed artillery system it is building for the U.S. Marine Corps and Army. BAE did not select RIA to produce the LW155 gun mounts/recoil system, indicating the lack of overwhelming economic advantage to doing so.

The one case that allows direct cost comparisons between a private sector producer and RIA is that of gun mounts for the Abrams tank. As mentioned earlier, gun mount production is split between GDLS and RIA. At the request of the PM for the Abrams tank, TACOM and OSC conducted three economic analyses over the last decade comparing the fully loaded production costs between the two producers.⁶⁰

⁶⁰Jansen, Lori, undated memorandum provided to the authors, "Summary for Gun Mount Study; 1993, 1994, 1997." The cost figures cited in the economic analyses have not been cleared for public release, thus only an overall assessment can be stated here. Detailed cost data were also requested from TACOM, which has collected this data from GDLS and RIA. These data were requested in order to make an independent assessment of this one case in which direct cost comparisons of identical arsenal and private-sector-produced military items was possible. These cost data were not approved for release to this study.

A short-term make/buy cost analysis was used in these analyses, based on the assumption that the government facility would continue to exist, regardless of the make/buy decision. For the government facility, the marginal, or out-of-pocket, cost of producing an item was compared with the price that would be charged by the contractor. Thus, the fixed overhead costs were excluded from RIA's costs because, in the short term, they would be incurred regardless of where the gun mounts were produced. The analyses also compared the fully loaded costs of production at RIA and the private facility. For RIA, these included both out-of-pocket costs and fixed overheads, but, for the contractor, they also included the cost of not doing business at the government facility—i.e., unabsorbed fixed overheads and the costs of laying off excess RIA employees. Under this type of analysis, RIA's costs are lower, although the price that would be charged by the contractor is lower than RIA's fully burdened costs. These studies should not be regarded as definitive as the costs were not taken from formal competitions that would have contained formal bid packages.

This kind of analysis is also exemplified by the Comptroller General's guidance concerning Arsenal Act implementation.⁶¹ In such analyses, the cost of production of an item at a government facility is calculated based on the out-of-pocket cost to the government to produce the item.⁶² In other words, the marginal cost of producing an item is used for the comparison and the fixed costs of the production facility are ignored. However, under the current financial guidelines that govern working capital fund organizations, such as the arsenals, the fixed costs are ultimately paid by the organization's customers. Thus, when a government PM is competing production of an item between a government facility and a private facility, the winner of the competition is based on the government facility's marginal cost, but, should the government facility win, the price paid by the PM is the fully loaded cost—i.e., the marginal cost, plus a share of the facility's fixed cost.

The difficulty with these short-term analyses is that they are based on the underlying assumption that the facility will remain open. When making long-term decisions about retaining production capacity in Army-owned arsenals, the facility's fixed overhead costs should be taken into account. A long-term analysis should compare the arsenal's fully loaded costs across its

⁶¹Office of the Inspector General, Department of the Army, "Procurement of Gun Mounts for the M1A2 Tank," Report No. 97-066, Arlington, Va., January 9, 1997.

⁶²Out-of-pocket costs include the direct labor, materials, and any indirect costs directly attributable to production of the item.

product range with the prices that contractors would charge to produce the same items. Such an analysis would be akin to a consumer comparing identical products from two independent producers. If one producer consistently charges a higher price, it will be forced out of the business, at no cost to the surviving producer.

From the limited data provided by OSC, short-term economic analysis supports the contention that RIA can produce Abrams gun mounts at a lower total cost to the government than can GDLS, assuming the Army must continue to pay RIA's fixed overhead costs. Such an analysis says little, however, about whether RIA could produce *all types* of gun mounts over the long term at a lower cost to the government than private suppliers could. The data also suggest a long-term conclusion that GDLS may produce gun mounts more cost-effectively than RIA, but the data are not conclusive

Cannon, Mount, and Towed Artillery (Worldwide) Production Options

Argentina*	Direccion General de Fabricaciones Militares (DGFM)	Currently capable or producing
Austria	Voest Alpine, Noricom	Not currently producing
Bulgaria	BETA plc of Cherven Briag	Not clear if still producing
China	Noinco	Currently capable or producing
Croatia*	RH Alan	Currently capable or producing
Egypt*	Abu Zaabal Engineering Industries Co. (Factory 100); Egyptian Tank Plant (Factory 200)	Currently capable or producing
Finland*	Patria Engineering (Patria Vammas)	Currently capable or producing
France*	GIAT	Currently capable or producing
Germany	Rheinmetall	Currently capable or producing
India*	Heavy Vehicle Factory (Bharat Forge?)	Currently capable or producing
Iran	Armament Industries Division, Defense Industrial Organization	Currently capable or producing
Iraq*		A couple of sources say producing again
Israel	Israeli Military Industries	Currently capable or producing
Italy	OTObreda	Currently capable or producing
Japan	Japan Steel Works	Currently capable or producing
Netherlands	RDM Technologies	Artillery but no cannon

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From a market analysis standpoint, knowing who produces cannon, gun mounts, and towed artillery is important for three reasons. First, if there are a number of producers around the world, overseas buys of these items become an option for the U.S. government. Second, if production of these items is pervasive, it is an indication that production is not too difficult, which could make it less risky to rely on the private sector for these items.

Third, most industrialized countries currently produce, or recently produced, these items. In most cases, however, the governments of these countries are significantly involved in the production. The involvement takes several forms. The most obvious is direct ownership of the means of production, and this form is the most prevalent. In some cases, the government provides a subsidy to the production facility to keep it solvent. In others, it guarantees production contracts to give workload to the facility and provide some stability.

Cannon, Mount, and Towed Artillery (Worldwide) Production Options (continued)

North Korea*	State Factories	Currently capable or producing
Romania*	RATMIL	Currently capable or producing
Russia*	Various state factories	Currently capable or producing
Serbia	Yugoimport (seems to represent many defense companies or state firms)	Currently capable or producing
Singapore*	Ordnance Developing & Engineering of Singapore	Currently capable or producing
Slovakia	ZTS Dubnica nad Vahom	Not clear if still producing
South Africa*	Denel	Currently capable or producing
South Korea*	KIA	Not currently producing
Spain	Santa Barbara	Claimed capability
Sweden*	Bofors	Currently capable or producing
Switzerland	Swiss Ordnance Enterprise	Currently capable or producing
Taiwan*	Combined Service Forces	Demonstrated capability
Ukraine	Kharkov Morozov Design Bureau	Currently capable or producing
United Kingdom*	BAE (Royal Ordnance)	Currently capable or producing
United States*	Watervliet Arsenal UDL, Louisville	Currently capable or producing

Unless noted, each country has the capability to produce large-caliber cannon. *Indicates the country currently, or recently, developed and produced a towed artillery weapon

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The bottom line, though, appears to be that few facilities are capable of surviving without some form of domestic government support.⁶³ The inability of companies to survive without government support may indicate worldwide overcapacity relative to demand or a problem with maintaining desired surge capacity.

With that in mind, there appears to be a trend toward privatization among producers of cannon, gun mounts, and towed artillery.⁶⁴ Private or semiprivate companies predominate now. These still generally have some sort of domestic government support, but that may be changing as the cost of maintaining these facilities with austere defense budgets becomes more onerous.

⁶³Foss, Christopher F., "Jane's Armour and Artillery," London: Jane's, 1996–1997, 1997–1998, 1998–2000. The basic identification of producers was accomplished with Jane's. This was followed up with more detailed research to get a general idea of whether production continues, how the producers are supported, and, if possible, current capacity. Additional research was through such sources as company Web pages and news reports.

⁶⁴Santa Barbara (Spain), Rheinmetall (Germany), Royal Ordnance (United Kingdom), OTO Breda (Italy), and Bofors (Sweden) are private cannon manufacturers in Europe. Private firms in Japan and Korea also manufacture, or have recently manufactured, large-caliber cannon.

For comparison with the U.S. Army's arsenals, two of Western Europe's producers of cannon, gun mounts, and towed artillery—Rheinmetall and RO Defence (formerly Royal Ordnance)—will be examined in the next two figures. In Rheinmetall's case and in contrast to the United States, the company has been private for decades. Royal Ordnance privatized a few years prior to the end of the Cold War. These cases are instructive studies in that they can be compared in terms of privatization.

Rheinmetall

- Integrated company (ammunition, cannon, and R&D to support both). Combines the functions of Benet, ARDEC, and Watervliet in one company
- Started downsizing when the Berlin Wall came down
 - Closed Düsseldorf facility and consolidated manufacture and engineering in Unterlüss
 - Built a cushion of product before consolidation to assist in the transition
 - Retired many workers over 56 years of age
- Makes ~185 cannons per year (primarily 55-caliber 120-mm tank cannon and 52-caliber 155-mm artillery cannon) with a 2X “surge” capacity
- ~50 personnel involved in cannon manufacture
- Expanded production through licensing with other manufacturers

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Rheinmetall is an integrated company that combines most of the functions of the U.S. Army's organic industrial base into one private-sector company. It develops, produces, and supports cannon, mounts, and ammunition for the German armed forces and for export. The advantage of being a private company is illustrated by the relative agility with which it dealt with the decline of its cannon market.

Prior to the end of the Cold War, Rheinmetall maintained two cannon production facilities: one in Düsseldorf and another in Unterlüss. With the fall of the Berlin Wall, Rheinmetall's cannon market dropped dramatically. In response, Rheinmetall stopped cannon production in the Düsseldorf facility and consolidated its cannon operations in Unterlüss. The company built a cushion of supply prior to shutting down the Düsseldorf facility to smooth the transition while Unterlüss was facilitated and the workforce was adjusted to manage all of Rheinmetall's cannon production. Sizing the workforce was accomplished by retiring affected employees aged 56 years and older. Additionally, many employees were unwilling to make the move to Unterlüss, helping to trim the overall size of the cannon production workforce.

The result is a facility more rationally sized, both in terms of plant size and workforce, to the market it supports. Approximately 50 direct labor

employees are involved in cannon production. Current production is about 185 tank and artillery cannon per year and capacity is double this rate. Acquisition programs for the German army (retubing Leopard tanks with "long" 120-mm cannon, new production of PZH2000 artillery systems, as well as normal spares production) and a fairly robust export program provides some stability to the current production rate. Importantly, though, Rheinmetall is also focusing on expanding production not only at Unterlüss, but also through licensed production with foreign partners.⁶⁵

⁶⁵Gaudet, Robert, Rheintech, Inc., representing Rheinmetall during discussions at Rheintech in McLean, Va., June 2, 2000.

RO Defence

- RO Defence is vertically integrated (ammunition, cannon, and R&D)
- Privatized in two steps
 - Government-owned corporation in 1985
 - Sold to British Aerospace in 1987
- Nottingham facility fulfills the UK's equivalent of RIA and WVA
 - Vertically integrated for making cannon, mortars, and artillery pieces
 - Current production ~70 cannon per year but declining
 - Capacity on a single shift is 120–150 cannon per year
- RO Defence is *closing* the Nottingham facility
 - Part of an overall consolidation scheme within RO Defence
 - Reestablishment of capability in Barrow will take 18 months
 - Loss of vertical integration (only finish machining and assembly are core; forging, chrome-plating, etc., will be subcontracted)
 - No surge/replenishment requirement, capability will be value-based

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Like Rheinmetall, RO Defence is an integrated company that combines most of the functions of the U.S. Army's organic industrial base in one private-sector company. It develops, produces, and supports cannon, mounts, and ammunition for the British armed forces and for export. Unlike Rheinmetall, Royal Ordnance was a government organization until 1985. During the late 1970s, a conservative government was elected in the United Kingdom (UK). A major goal of the conservatives was the privatization of much of the country's extensive government-owned industrial base, and Royal Ordnance was caught up in this movement. In 1985, it became a government-owned corporation and was sold to British Aerospace (BAE) two years later.

RO Defence produces cannon and towed artillery at its Nottingham facility. In many ways, this facility is similar to a combined WVA and RIA because it is vertically integrated for all aspects of production of these items. As with most ordnance producers, production at Nottingham has declined significantly. It currently makes only 70 cannon per year and even that rate of production is not sustainable. That overcapacity is a problem is indicated by the Nottingham facility's capability of producing at twice its current rate on a single shift. With production requirements declining, overcapacity at Nottingham became too much of a drag on BAE's bottom line. As a result, the Nottingham facility is being closed as part of an overall BAE

consolidation. The real property will be sold and the equipment either transferred to other BAE facilities, sold, or scrapped.

RO Defence's capability for making the cannon and towed artillery will be reestablished at its Barrow facility in a process that should take about 18 months. RO Defence, however, will make significant capability and capacity changes when Barrow is facilitated. For example, Barrow will not be vertically integrated in the same way that Nottingham was. RO Defence will maintain only finish machining and assembly at Barrow. This means that most other production processes, such as forging and chrome-plating, will need to be outsourced. Additionally, and perhaps more significantly, capacity will be sized to maximize profits rather than to meet some war plans requirement of the Ministry of Defence.⁶⁶

The Rheinmetall and RO Defence cases are of interest because of the parallels between them and potential parallels to the U.S. case. Additionally and to a certain extent, the three lie on a continuum, using time since privatization as a measure (Rheinmetall at one end; RO Defence, being recently privatized, in the middle; and the U.S. arsenals, still government-owned, at the other end). The manner and dispatch with which the three cases dealt with their similar overcapacity problems may be illustrative of what it means to be at the different points on the continuum. Certainly the bottom-line motivation of the private companies has accelerated their consolidation activities relative to the United States. RO Defence seems to have delayed somewhat compared to Rheinmetall as a result of its recent government ownership. Finally, the United States continues to debate consolidation of its arsenals and has begun significant footprint reductions within the individual arsenals.

⁶⁶Cresswell, John, and David Mather, both from RO Defence, during discussions and a plant tour at RO Defence's Nottingham, UK, facility, September 4, 2000.

Cannon, Gun Mount, and Artillery Production Observations

- **Significant overcapacity for cannon, mount, and artillery production**
 - Army owns five times capacity for peacetime plus replenishment production (single shift)
 - Additional private capacity exists
- **Unique capability of the arsenals is vertically integrated manufacture**
 - Few manufacturers try to do everything, instead concentrate on core capabilities
 - Many successful ordnance manufacturers shop out some processes
- **Competition exists for the items made by the arsenals**

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Several observations can be made after completing a market analysis for the ordnance items produced by the U.S. Army's arsenals, RIA and WVA.

First, the United States clearly has an overcapacity problem with regard to cannon, gun mount, and towed artillery manufacture. Neither the plant footprint nor the workforce appears to be rationally sized to the market they support. On a single-shift basis, the U.S. government has the capacity for five times the production requirements for these items. And, because the equipment at the arsenals was designed to support high rates of production, it is not possible to reduce that capacity to meet current low production and replenishment requirements. For example, a lathe needed to support current production and replenishment may have 20 times the required capacity, but it would make little sense to sell this fully amortized machine only to buy a less capable one. Instead, the answer may lie in finding ways to bring more production to the existing equipment.

Additional private capacity exacerbates the situation and, in the case of RIA, is winning away most of the business. In the case of WVA, the threat of losing business to the private sector also appears to be growing.

Second, the U.S. Army argues that the vertically integrated nature of its arsenals is a unique and important capability that provides the Army with unparalleled responsiveness with regard to ordnance items. The validity of

this argument is an open question. It is noteworthy that few manufacturers of other items have retained vertical integration. Most identify their key competencies and concentrate on those while outsourcing the remainder of the manufacturing process. Not only is it more economical for them to do so, but quality improves by concentrating on what is done best and responsiveness can be managed through the supply chain. OSC argues that vertical integration contributes to responsiveness because government ownership of all the assets in one place permits the Army to avoid the contracting and acquisition regulations that take time to bring civilian firms on line. It is also worth noting that many ordnance producers, such as Rheinmetall, have successfully forgone complete vertical integration.

Finally, it is clear that competitors to the U.S. Army's arsenals exist, both domestically and overseas. The recent actions surrounding the LW155 production decisions indicate that competition for production of ordnance items will probably prove even more trying for the arsenals in the future.

Ammunition Market Surveys

- **Need to have a focus to get at details**
 - Current survey is to allow top-level consideration of organic base options
- **Government market surveys have relied on:**
 - Requests for information
 - Announcements that sources are being sought
 - Competitive solicitations
 - Some follow-up visits
- **Information on overseas suppliers is very limited**

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The ammunition market is more complex than that for the ordnance items. This is simply because ammunition is much more varied. In the earlier discussion of ordnance items there were, for our purposes, really just two categories: large-caliber cannon and gun mounts/towed artillery systems (which could probably be more broadly defined as being primarily the recoil systems). Ammunition includes a larger number of items that range from .22-caliber pistol bullets to 2,000-pound penetrator bombs.

Additionally, ammunition components are quite varied, and no facility is integrated to produce all the components of an ammunition end item in the manner of WVA and RIA. For example, a single ammunition item may contain an electronic fuze, large metal parts, an explosive warhead, propellants, and a combustible cartridge case—all of which are manufactured at a variety of government and commercial facilities. Final assembly of the end item also takes place at a number of government and commercial facilities.

Given the level of complexity of this market, determining the level of detail required of an ammunition market analysis is important and depends on the purpose for conducting the analysis. In this case, the purpose is to assist in a top-level consideration of the four options for the Army's organic industrial base as identified in Chapter 3 of this study:

- privatize
- create an FGC
- consolidate
- recapitalize and unify.

In this context, a top-level understanding of the ammunition market primarily helps to inform the first option. In other words, the understanding need only be deep enough to determine whether potential privatization of at least some parts of the Army's organic industrial base warrants further detailed analysis during Phase 3 of the study.

Also, because of the complexity of the ammunition market, we draw on analyses of this market previously completed by the government. As part of its mission of supporting the Army with ammunition, OSC conducts selective ammunition market analyses. Initial market research and producer identification use such tools as the Internet and specialty publications. These sources are necessarily limited, however, because of the nature of the military ammunition market. As a result, the most in-depth market surveys result from publication of RFIs in the Commerce Business Daily (CBD). OSC personnel follow up responsive replies with detailed questions and sometimes with site visits. What this usually means in practice is that only companies that have a current interest in producing ammunition for the U.S. government are included in the analyses.⁶⁷

Additionally, because many ammunition components are considered critical items that should not be procured from other than U.S. or Canadian sources (and the published notices state this), these analyses are often only useful in understanding the current state of the domestic ammunition market. Unlike the market for ordnance items, in which PMs have shown a recent willingness to look overseas, the Army's focus on American ammunition suppliers has made it more difficult to find detailed information concerning overseas suppliers.⁶⁸

This makes an understanding of the foreign ammunition market more difficult. These potential sources of ammunition are understandably reluctant to provide detailed information concerning capability and capacity unless doing so will provide a competitive advantage. Because most overseas ammunition is excluded, in a practical sense, from the U.S. market, this detailed information is necessarily limited.

⁶⁷Personal communications with various OSC personnel, summer and fall 2000.

⁶⁸10 USC 2304 emphasizes the focus on American ammunition suppliers.

Characterizing Ammunition Production

- **Large replenishment requirements for warfighting rounds**
 - Production requirements peak during and after a war
 - Much smaller, or absent, peacetime production requirements
- **Enduring designs—typically little in the way of design change during the life-cycle of an ammunition item**
- **Specialized manufacture**
 - Safety issues
 - Environmental concerns
 - Quality requirements
- **Government as a customer**
 - Many ammunition items have no commercial counterpart
 - Funding and schedule risks with government as the only customer

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Ammunition production has several distinctive characteristics. First, and perhaps most important, the requirement for warfighting rounds peaks during wars and during the replenishment period that follows wars. Use of these rounds is often restricted during peacetime for cost, environmental, and safety reasons. The practical effect of this characteristic is often very large replenishment requirements for warfighting ammunition but little or no peacetime production after sufficient supplies of the ammunition have been initially procured. Therefore, either underutilized capacity must be maintained during peacetime or the risk associated with closing a line and then reestablishing it when needed must be accepted.

To a certain extent, this is related to another ammunition characteristic: enduring designs. For conventional ammunition, as opposed to such munitions as missiles, the Army has decided to maintain the capacity needed to produce replenishment quantities in the wake of national emergencies. Because warfighting ammunition is typically produced in batches, and the production line idled at the end of the batch, often little or no change in ammunition design occurs between production runs.

Ammunition production is also somewhat specialized for safety, environmental, and quality reasons. Manufacture of energetic materials or of ammunition components containing energetic materials requires

sufficient real estate to provide an explosive safety distance for the quantity of material being produced and stored. Additional safety measures must also be taken at the point of manufacture because of the hazards the energetic materials present to the personnel involved in its manufacture. Environmental hazards are also a factor in the production of certain ammunition components. Many of the chemicals and processes used in the production of energetics, smokes, and illuminants present unique environmental challenges. Moreover, the need for very high levels of quality makes ammunition production look somewhat specialized. The extreme operating environments in which ammunition must function, the consequences associated with a failure to function, and the ability to fully test only a very small fraction of the items produced (because full testing results in destruction of the item) combine into a requirement that ammunition be manufactured to very high quality standards.

Finally, the government is the only customer for most military ammunition items. No commercial production is available to mitigate the risk associated with having a single, fickle, government customer. As a result, funding cuts, schedule slips, and changing requirements can have very significant, and usually adverse, effects on the ammunition producers.

Competition in the Ammunition Realm

- **Full and Open—Competition open globally**
- **Restricted—limited to North American suppliers or to specific contractors**
 - Individual items
 - Classes of items—e.g., small arms
- **Competition to run/maintain ammunition facilities**
 - Facilities use contract at Mississippi
- **Competition to run ammunition facilities and provide product**
 - Pending Radford competition
- **Directed workload**

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One result of the unique nature of military ammunition, among other things, is that the makeup of the ammunition industrial base is also rather unique. It consists of a combination of GOGO plants; GOCO plants; and contractor-owned, contractor-operated (COCO) plants. This industrial base makeup, combined with the perceived criticality of ammunition and congressional direction in some cases, has resulted in a complicated mix of competition and make/buy strategies.

Some items are still obtained using full and open competition. This means that once a solicitation for ammunition production is placed in the CBD, anyone around the world is free to make an offer for that production.⁶⁹

Often, particular ammunition types or ammunition components are considered so critical to the Army mission that their production is restricted to the United States and Canada. Additionally, production will often be restricted to certain producers for reasons of efficiency or schedule. For example, if certain suppliers have been providing a particular ammunition component or type for a number of years, competition for that item may be

⁶⁹For example, solicitation N00164-99-R-0084, "The Government intends to procure, under full and open competition, 0.50 Caliber Armor-Piercing Ammunition capable of being used in the M2HB and XM218 machine guns."

restricted to the known suppliers to ensure that requirements are met in a timely and efficient manner.⁷⁰

In addition to the competitions for the production of ammunition and ammunition components, the Army solicits competition for the facilities use contracts it issues to run the GOCO ammunition facilities. Recent awards have been for as long as 25 years. Typically, once a contractor is established in a facility, it is likely to remain in the facility for an extended period. For example, Day and Zimmerman, Inc., has run Lone Star AAP for nearly 50 years and Norris Industries has run Riverbank AAP for about the same length of time. Contractors do change occasionally and some significant changes have occurred in the last few years: notably Lake City AAP's contractor changed from OlinWinchester to Alliant Techsystems, BAE took over Holston AAP, and operation of Louisiana AAP went from Thiokol to Valentec.

In other cases, competition for production of ammunition is intrinsically wrapped up in the competition for managing the production facility. To a large extent, this appears to be what happened with respect to the competition for small arms ammunition production. In that case, potential competitors were given the option of not using Lake City AAP, but the manner of the solicitation virtually guaranteed that any responsive bid would be required to use the Army's organic facility.⁷¹ The competition for running Radford AAP will probably be bundled in a similar manner because it will likely require a proposal for both production and facility management.

Finally, workload may be directed to a particular ammunition plant without any competition. This is typically done when maintenance of a production capability at a particular facility is considered critical.

⁷⁰For example, solicitation DAAE30-99-R-0521 regarding Multi-Option Fuze for Artillery (MOFA), "The proposed acquisition strategy directs initial production for FY99 and FY00 (Option FY01) sole-source to Alliant Techsystems, the competitively selected development contractor. The U.S. Army plans to pursue follow-on production through a competitively awarded multi year contract for FY01-05, limiting competition to U.S. and Canada sources." Also see Justification and Approval for Other Than Full and Open Competition, Control No.: 980031, Program/Item: 120-mm Tank Training Ammunition, OSC, U.S. Army, Rock Island, Ill., January 1998.

⁷¹The solicitation calls for current production, replenishment production preparedness, and a plan for Lake City AAP. It also allows for use of Lake City AAP free of charge for the production of small arms ammunition. <http://www.ioc.army.mil/ac/aaais/ioc/solinfo/sow/SECOND-PHASE-SOLICITATION.html>.

Products and Processes in the Organic Base

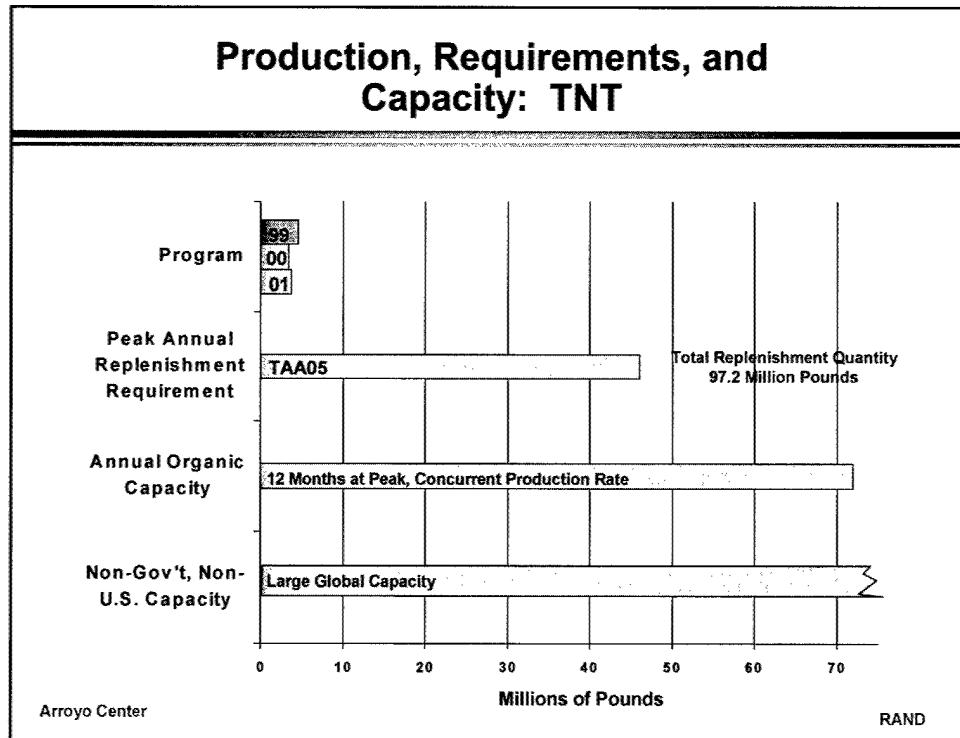
- Explosives
 - Military explosives
 - TNT
 - Black powder
- Propellants
 - Single base
 - Multiple base
 - Solventless
- Small Caliber
- Medium caliber
- Metal Parts
 - Large-caliber projectiles
 - Cargo grenades
 - Deep-drawn cartridge cases
- LAP
 - Filler
 - Pressed
 - Melt pour
 - Cold cast cure
 - Extrusion
 - Tank Projectile
 - Specialized
 - ICM
 - FASCAM
 - Illumination
 - Smoke
- Other Components
 - Delays, relays, primers, and detonators
 - Illumination candles

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The ammunition market analysis focuses on those items produced in the organic base, though this is a somewhat simplified view, given the complicated interactions between commercially produced items, such as fuzes, and items produced in the organic base.

The items on the left side of this figure through to metal parts are examined for the ammunition market analysis, though greater detail will certainly be required for Phase 3 purposes. Analysis of LAP has begun but will need more attention through Phase 3. Finally, examination of "Other Components" will need to begin during Phase 3.



This figure and similar ones that follow resemble those shown earlier for cannon and gun mounts.⁷² Program figures come from the FY99 Production Base Plan (PBP). The total replenishment requirement comes from the TAA for 2005 (TAA05), which the PBP uses for replenishment planning purposes. The Army has not yet completed its PBP for the TAA07 requirements. The annual rate at which the products would be required to be produced in a three-year replenishment scenario is estimated through reference to the production lead time for the item as identified in the PBP, subtracting that lead time from a 36-month replenishment period⁷³ and spreading the replenishment requirement over the remaining time. One should not infer that this peak rate can be achieved immediately. The current annual organic capacity to manufacture those products is based on the maximum production rate identified in the PBP. The global capacity has not been quantified, only characterized.

This figure focuses on trinitrotoluene (TNT).

⁷²The Production Base Plan is the source for ammunition requirements and organic base capacities in the rest of this report. OSC, "SMCA Production Base Plan Publications and Reports," Rock Island Arsenal, Ill., September 22, 1999.

⁷³Although the PBP is still based on a 36-month replenishment period, current policy no longer specifies any particular period for replenishment of ammunition.

Two clear messages emerge from the figure above. First, replenishment demand for TNT is significantly larger than the current requirement. This seems intuitive in that it is not usually desirable for training ammunition, which makes up the bulk of current ammunition requirements, to be highly explosive. The impact however, is the need to have adequate TNT production capacity, or sources of TNT, available to meet replenishment requirements. Second, the current capacity within the organic base can easily meet stated replenishment requirements.

TNT

- **No production at Radford since 1986, and no North American production**
 - Estimated cost to reestablish domestic production at Radford: \$12 million–\$50 million
 - Time to start production: 10 months
- **Relying on stockpile and reclamation for peacetime requirements**
- **Significant domestic production of explosives (> 2 million tons)**
 - Primarily ammonium nitrate; nitration of ammonia, rather than toluene
 - Peacetime TNT buys for military are one-tenth of 1 percent
- **Overseas**
 - Potentially a lot of sources with capacity to replenish U.S. stockpiles. Cost: \$1.00 to \$2.00 per pound
 - Former Warsaw Pact—Russia, Romania, Ukraine, Bulgaria
 - NATO—UK, France
 - Other—Sweden, Switzerland, South Africa, China
 - Unresolved issues with using overseas sources of TNT
 - Quality of product
 - Reliability in a replenishment scenario

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TNT is one of the more important explosives. It is used as an explosive filler both by itself and mixed with other explosives in a very large number of military ammunition items.⁷⁴ Radford AAP now has the only large-scale production lines for TNT in North America, and those lines are idle. Despite the military importance of TNT and the sole-source status of Radford AAP, TNT has not been produced there for almost 15 years. In fact, no other North American supplier of TNT has existed since the sole Canadian supplier exited the business a number of years ago. A principal result of nonproduction in North America is that the cost and time required to restart the TNT production lines at Radford AAP are significant. Depending on the source of the estimate, the cost to restart production is anywhere from \$12 million to \$50 million and would take nearly a year.⁷⁵

Because no current production of TNT takes place in North America, the United States is relying on its stockpile of TNT and reclamation of TNT from items being demilitarized to meet current requirements. These

⁷⁴Rheinmetall, "Handbook on Weaponry," Frankfurt, Germany: Brönners Druckerei Breidenstein GmbH, 1982.

⁷⁵Discussions with OSC staff at RIA, November 2, 2000, and authors' discussions and impressions during a site visit to Radford AAP, September 2000.

sources of TNT are not expected to last more than a few more years and would certainly be inadequate in a replenishment scenario.

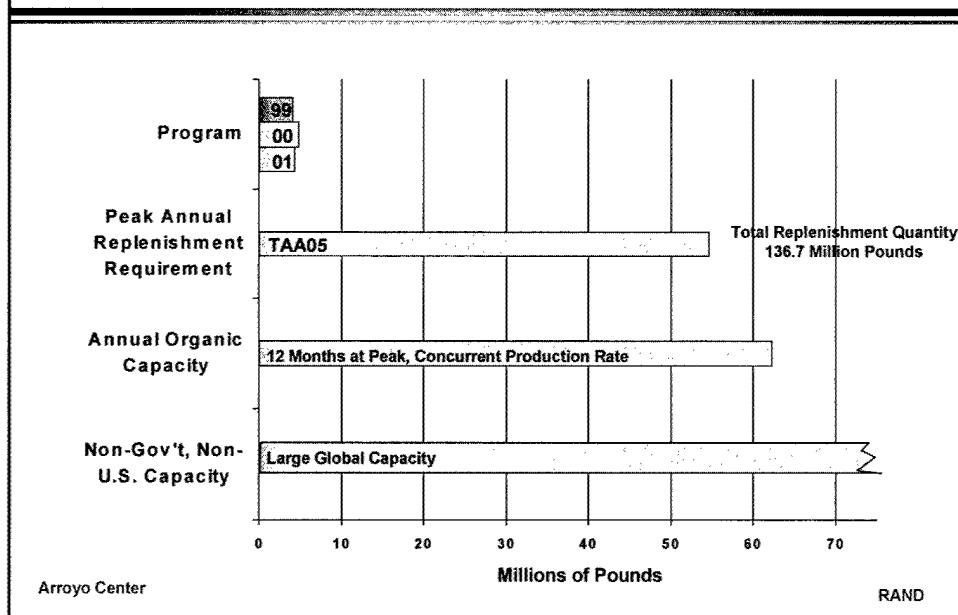
A significant commercial explosives industry exists in the United States that produces more than two million tons of explosives a year—a quantity that dwarfs the requirement for military TNT. These explosives are used primarily in the mining and construction industries.⁷⁶ Production of commercial explosives, which are almost entirely ammonium nitrate products, is different than TNT production in that nitration is of ammonia rather than toluene. Quality and processing requirements of the finished product also differentiate military TNT from commercial explosive production.

Significant TNT production capacity exists overseas. Because it is such an important military explosive, a number of countries established facilities to make TNT to ensure adequate supplies during military emergencies. Importantly, countries with low labor and environmental compliance costs, such as in the former Warsaw Pact and in China, maintain current TNT production capacity and can provide it at low prices. Western countries, such as the United Kingdom, France, and Switzerland, also maintain capacity, and claim to trade high quality for cost. Depending on the source, the price of TNT can be less than a dollar per pound to as much as two dollars per pound.⁷⁷ Because the United States has, in the past, relied on domestic and Canadian suppliers and now relies on its TNT stockpile, the actual quality of foreign TNT would need to be thoroughly evaluated before committing to a new foreign source. Additionally, the political, military, and economic reliability of any foreign source would need to be carefully weighed to ensure that the risk of relying on it is acceptable.

⁷⁶Kramer, Deborah A. "Explosives," *Minerals Yearbook: Volume I—Metals and Minerals*, United States Geologic Survey, Reston, Va., 1999, <http://minerals.usgs.gov/minerals/pubs/commodity/explosives>.

⁷⁷Vinh, Paul (Armaments Research, Engineering, and Development Center) and Paul Sundberg (Operations Support Command), "World-wide Market Survey for Trinitrotoluene (TNT) Sources Final Report," Rock Island, Ill., January 2000. This market survey discussed four TNT sources. Other possible sources were identified through Internet searches.

Requirement for Military Explosives (RDX, HMX, various comps., etc.)



In addition to TNT there are a number of other very significant military explosives—the bulk of which are, by weight, RDX, HMX, and mixtures containing them. This figure focuses on these military explosives and tells a story similar to that for TNT: (1) replenishment demand for these explosives is significantly larger than the current requirement, forcing the Army to have adequate production capacity or sources of military explosives available to meet replenishment requirements and (2) the current capacity within the organic base can easily meet stated replenishment requirements. The aggregated figures shown here mask any issues specific to individual products. These figures are indicative of a general capacity sufficiency. No specific capacity problems have been discovered.

Military Explosives

- **Most North American production at Holston AAP**
 - Time to start replenishment levels of production: five months
 - Warm production base at Holston AAP
- **Some commercial production of military explosives in the United States**
 - R&D quantities of newer explosives (CL20, TNAZ)
 - Some explosives made on contractor facilities but may use constituent materials made by Holston
 - Some quantities for commercial use (det cord, boosters, etc.), pharmaceuticals, and other uses. Total capacity is unknown, but limited
 - Commercial explosives industry limitations
- **Overseas**
 - Potentially a lot of sources with combined capacity to replenish U.S. stockpile
 - Former Warsaw Pact, NATO, other (similar to TNT overseas base)
 - Unresolved issues with using overseas sources of military explosives
 - Quality of product
 - Reliability in a replenishment scenario

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Holston AAP is far and away the largest producer of non-TNT military explosives in the United States. BAE recently won the contract to run Holston AAP and has restarted production of certain explosives.

Additionally, since taking over, BAE has made improvements to the facilities and production processes at Holston AAP and is planning to move some of its explosives production from the United Kingdom.⁷⁸ All this means that, unlike TNT, military explosives production at Holston AAP will run in a “warm” status, making ramp-up to replenishment rates of production somewhat easier. The PBP estimate for replenishment production lead time at Holston AAP is five months.

In addition to Holston AAP, some commercial suppliers make military type explosives, including Expro, a Canadian firm. There is a market for some of these products in commercial industries that rely on explosives, such as mining and road construction. They generally use military-type explosives in such applications as detonation cord, ignitors, and boosters. Interestingly, the pharmaceutical industry also makes use of similar compositions.

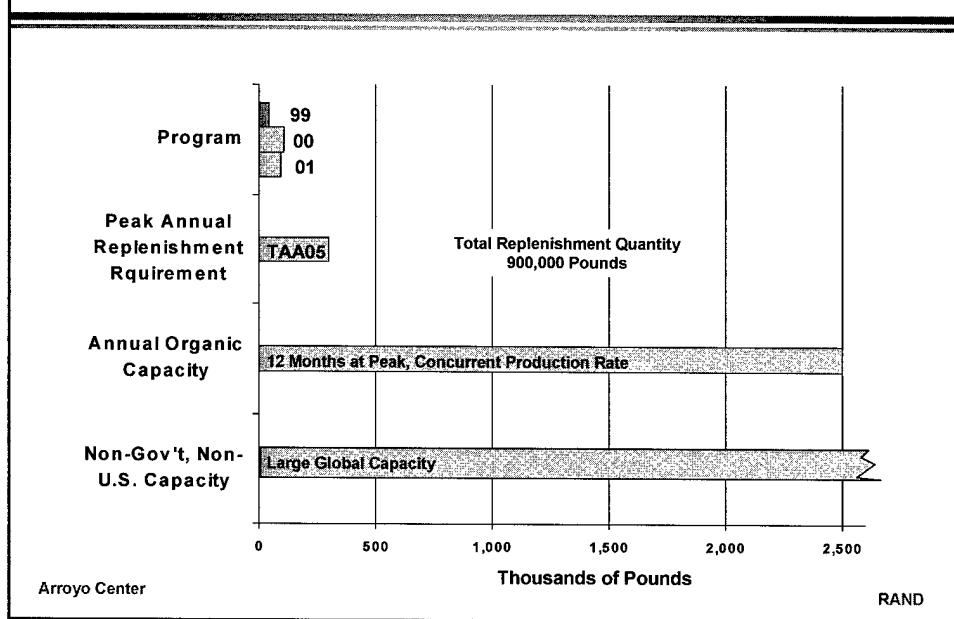
⁷⁸Authors' discussions and impressions during a site visit to Holston AAP, September 2000.

The commercial base has very significant limitations. The largest concerns capacity. Domestic makers of military explosives normally produce quantities sufficient for limited application, such as R&D. It also appears that these producers often obtain the constituent materials for their products from Holston AAP.

The same limitations concerning the industrial explosives base as a potential supplier of TNT also apply to the other military explosives. The processes are somewhat similar in that they usually involve the nitration of some compound but are different enough in terms of required product quality and finishing processing that significant facilitization of the commercial plants would be required to make military explosives in replenishment quantities. Because the current demand for military explosives is very small compared to the market for industrial explosives, the producers of industrial explosives are likely to be reluctant to enter the military market.

Again as with TNT and for the same reasons, a number of overseas sources exist for military explosives. In a similar manner, though these represent potential sources of military explosives for the United States, the quality of the product and reliability of the supplier in a replenishment scenario would need detailed assessment prior to accepting any foreign supplier as a replenishment source.

Requirement for Black Powder



Black powder is the last of the important military explosives. The figure conveys the now-familiar story: large replenishment requirements relative to peacetime production but much larger organic capacity.

Black Powder

- GOEX, located at Louisiana AAP, is the only North American black powder producer. Produces most black powder consumed in the United States
- Military is a small part of GOEX's customer base (~5%)
 - Mining and construction, fireworks, black powder firearms
- Overseas sources available. Capacity is unknown but could probably meet U.S. Army needs
 - Slovenia, Brazil, China, Germany, and Switzerland
- Substitute materials becoming available

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Black powder is important as a part of the ignition train in many types of ammunition. There is currently only one significant producer of black powder in North America: GOEX, which is located at Louisiana AAP and provides the majority of the product consumed in the United States.⁷⁹

In addition to its use in military ammunition, black powder has a number of other uses. As a result, the military consumes only about 5 percent of the black powder produced by GOEX, which helps ensure that more than adequate capacity to produce black powder in a replenishment scenario exists.⁸⁰

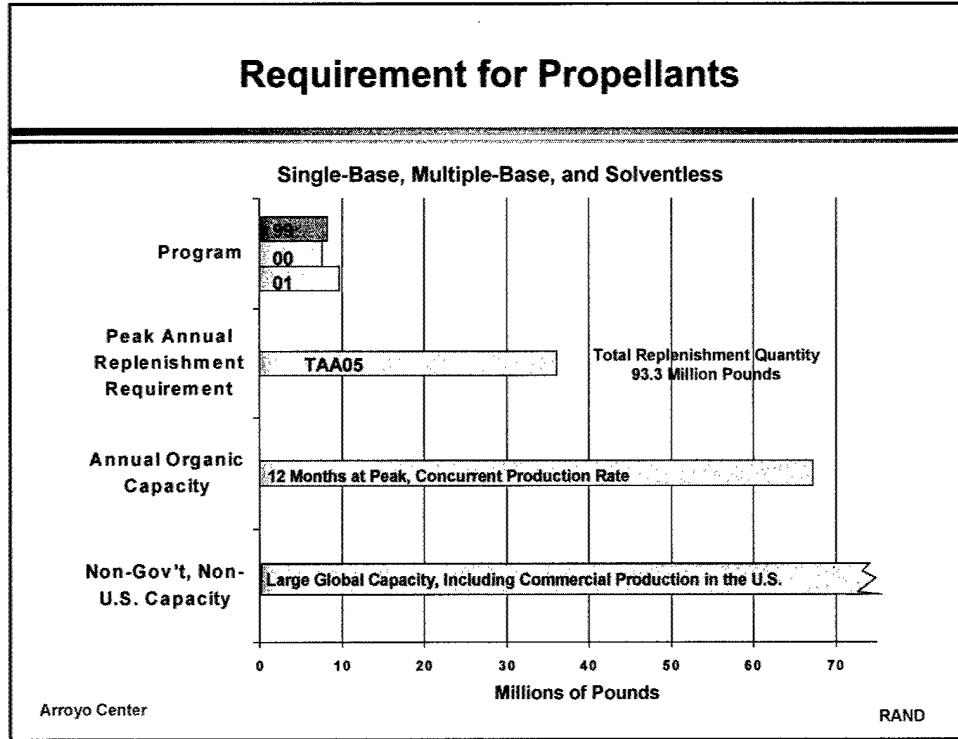
A number of foreign producers, Swiss and Chinese, for example, export black powder to North America. Their total capacity is unknown but, given the other uses for the product, could probably provide black powder to the U.S. government if required.

⁷⁹Committee on Smokeless and Black Powder, Board on Chemical Sciences and Technology, Commission on Physical Sciences, Mathematics, and Applications, National Research Council, "Black and Smokeless Powders: Technologies for Finding Bombs and the Bomb Makers," National Academy Press, Washington, D.C., 1998, http://books.nap.edu/books/0309062462/html/22.html#page_middle.

⁸⁰Beuster, Alan R., during discussions at Rock Island Arsenal, November 2, 2000.

Finally, and importantly, substitute products are becoming available.⁸¹

⁸¹Commercial substitutes for black powder include Pyrodex® and Clean Shot Powder®. Use of these substitutes is a long-term effort involving a substantial amount of testing to prove the substitutes' characteristics and to qualify them in the various ammunition items that use black powder.



This figure focuses on propellants, which fall into several broad categories: single-base propellant (basically nitrocellulose), multiple-base propellants (nitrocellulose further nitrated with nitroglycerin in the case of double-base propellants and even further nitrated with nitroguanidine in the case of triple-base propellants), and solventless propellants.

The aggregated figures for single-base, multiple-base, and solventless propellants reveal a ratio of annual replenishment to programmed production of between three to one and four to one. But this aggregation masks a much higher ratio—around 11 to one—for multiple-base propellants. This is primarily the result of a very high artillery propelling charge requirements and, in fact, the capacity to produce multiple-base propellants is currently inadequate.⁸²

⁸²According to the PBP, the required peak annual replenishment production for multiple-base propellants is about 21 million pounds, while annual organic capacity is approximately 1.3 million pounds.

Propellants

- **Single-Base (Nitrocellulose propellants)**
 - Made by Alliant (Radford)
 - Nitrocellulose is used in other products (lacquer, plastics) but generally of different grade. Indication that there is excess global nitrocellulose capacity
 - Significant overseas production; most countries with munitions industry produce single-base propellants
- **Multiple-Base**
 - Primarily made by Alliant (Radford) and Primex (Saint Marks)
 - Primex is proprietary source of double-base ball propellant. Provides ~4 million pounds a year from large Saint Marks facility and responsible for 22 million pound replenishment requirement. Substitutes (IMR propellant) available
 - Expro has provided propellant to ammunition system contractors
 - Significant overseas production; unknown capacity
- **Commercial demand for small arms propellants is large. North American manufacture for the commercial base is dominated by Primex, Alliant, and Expro**

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The basic ingredient of single-base propellants, which are used in tank, artillery, and small-caliber rounds, is nitrocellulose. DoD primarily relies on production at Radford AAP to meet its needs for this product.

Because nitrocellulose is such a basic material in ammunition production, most every country that manufactures ammunition also manufactures nitrocellulose. In fact, there is probably excess global nitrocellulose production.⁸³ Nitrocellulose could probably be acquired overseas at a good price, but, again, the risk of doing so would need careful assessment.

Nitrocellulose also has application in a number of different products, which would seem to indicate a commercial capability.⁸⁴ Generally, though, the nitrocellulose used in other applications is of a different grade than when it is used as a gun propellant. When used as a gun propellant, the nitration of the cellulose is normally more complete and implies a somewhat different manufacturing technique.

⁸³ "Hercules Will Phase Out Nitrocellulose Business," *Business Wire*, December 10, 1999, http://www.findarticles.com/m0EIN/1999_Dec_10/58151011/p1/article.html.

⁸⁴ BioSupplyNet (http://www.biosupplynet.com/cfdocs/products/prod_supp.cfm?prod_id=685) claims 38 suppliers of nitrocellulose, not including Alliant and Primex.

Multiple-base propellants are made both on government facilities (by Alliant at Radford AAP) and on private facilities (by Primex at their Saint Marks, Fla., facility). The process of making ball propellant, used in many types of ammunition, is proprietary to Primex, and hence it is the sole producer. Primex's capacity is 10 million to 16 million pounds,⁸⁵ of which 4 million pounds is current production for the U.S. military. Primex has a 22 million pound replenishment requirement. However, Alliant makes a proprietary propellant that is considered acceptable.⁸⁶

In addition to Alliant and Primex, Expro of Canada has provided propellant on a subcontractor basis to U.S. ammunition system contractors.⁸⁷

The large size of the U.S. market for nonmilitary small arms ammunition implies a large market for nonmilitary gun propellant, and indeed that is the case (10 million pounds of smokeless propellants sold annually). The major North American producers that supply this market, though, are the same ones that supply the military propellant market: Alliant, Primex, and Expro. In addition, a quantity of this product is imported each year, implying that potential overseas sources of propellants exist for the U.S. military.⁸⁸

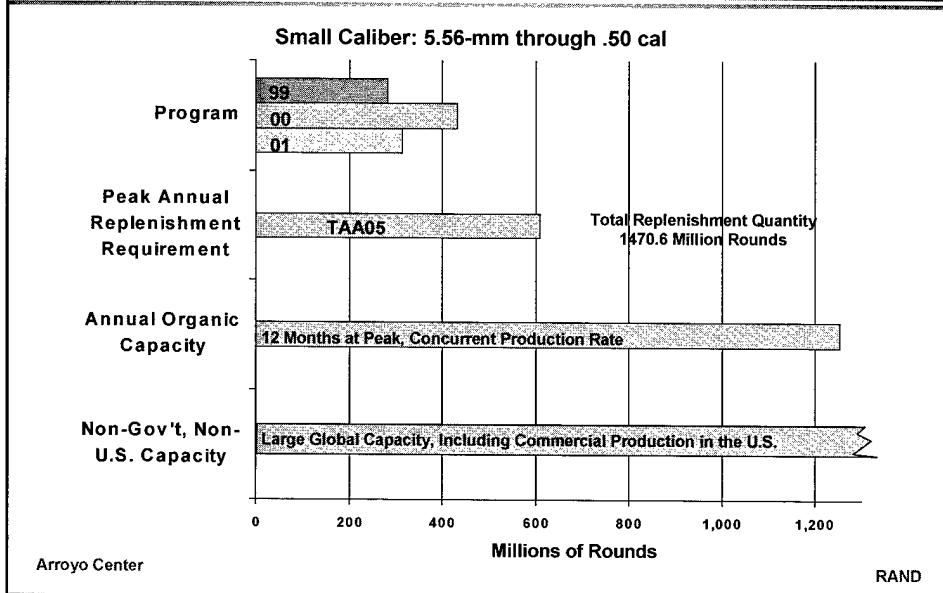
⁸⁵Committee on Smokeless and Black Powder, Board on Chemical Sciences and Technology, Commission on Physical Sciences, Mathematics, and Applications, National Research Council, "Black and Smokeless Powders: Technologies for Finding Bombs and the Bomb Makers," National Academy Press, Washington, D.C., 1998, http://books.nap.edu/books/0309062462/html/133.html#page_middle.

⁸⁶Beuster, Alan R., during discussions at Rock Island Arsenal, November 2-3, 2000.

⁸⁷*Ibid.*

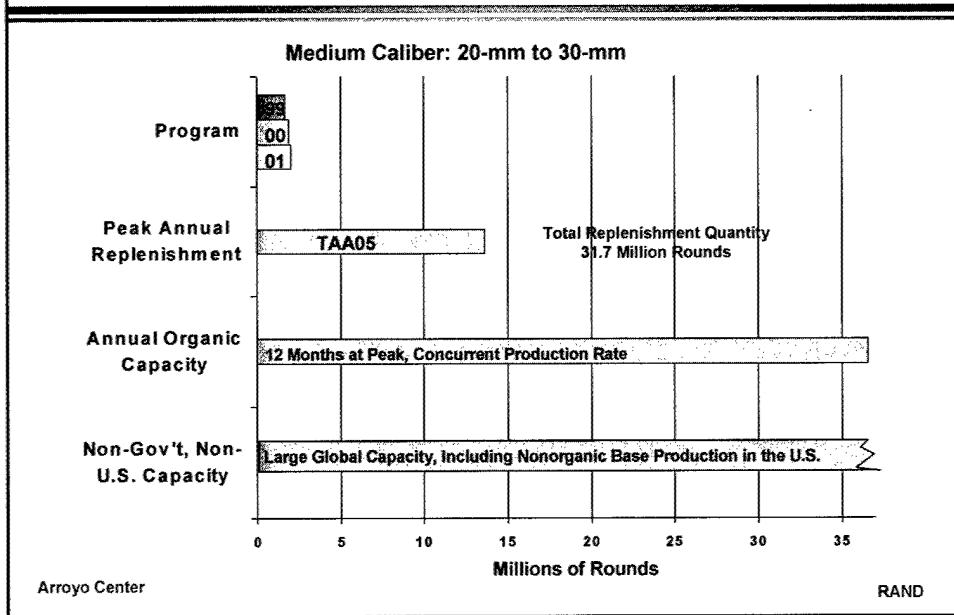
⁸⁸Committee on Smokeless and Black Powder, Board on Chemical Sciences and Technology, Commission on Physical Sciences, Mathematics, and Applications, National Research Council, "Black and Smokeless Powders: Technologies for Finding Bombs and the Bomb Makers," National Academy Press, Washington, D.C., 1998, http://books.nap.edu/books/0309062462/html/23.html#page_middle.

Requirement for Small-Caliber Ammunition



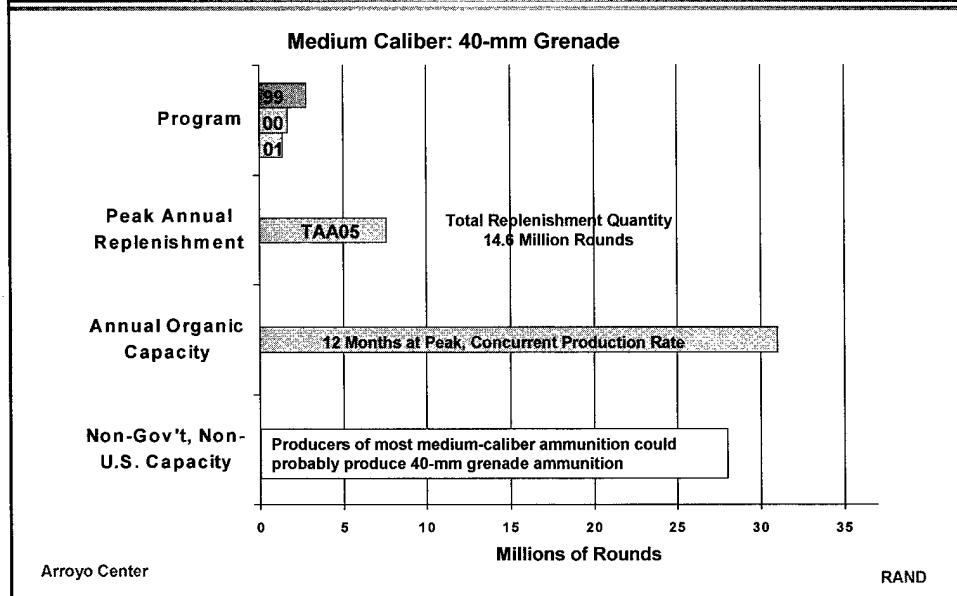
The services expend a lot of small-caliber ammunition during training. This programmed requirement reduces the ratio of replenishment to programmed needs below what we observed for energetics. Organic capacity is sufficient, and worldwide capacity is quite large.

Requirement for Medium-Caliber Ammunition



For medium-caliber ammunition, the situation is somewhat different from that for small arms. Replenishment requirements are significantly larger than current production, though like small arms, there appears to be more than sufficient capacity in the organic base to meet these requirements. Again, global capacity is substantial.

Requirement for Medium-Caliber Ammunition (40-mm Grenade)



Like ammunition between 20-mm and 30-mm, 40-mm ammunition—treated separately here because it is treated somewhat differently in production—exhibits a large ratio of replenishment to current requirements. Again, though, the capacity estimated in the PBP seems more than adequate to meet the requirement. Further research is required to assess global capacities.

Small and Medium Caliber

- **Lake City AAP produces most Army small arms ammunition**
 - Bundled (most 5.56 through 50 cal) five-year production contract to Alliant, with Lake City AAP on a 25 year facilities contract
 - Large small arms ammunition industry in the United States (~5 billion rounds annually), dominated by eight larger companies
 - Significant, but unknown, overseas capacity (Hirtenberger, Nammo Lapua, etc.)
- **Medium caliber (20-mm to 30-mm)**
 - Alliant (Radford AAP) and Primex (Marion) are medium-caliber producers
 - Primex has additional replenishment capacity of 34 million rounds
 - Significant, but unknown, overseas capacity (BAE, GIAT, Diehl, IMI)
- **Medium caliber (40-mm)**
 - Replenishment requirement for most with Milan AAP. Some at Pine Bluff Arsenal and McAlester AAP
 - Other medium-caliber capacity as noted for Alliant and Radford

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Most small arms ammunition produced for the U.S. military is made at Lake City AAP, though some types, particularly those that have a large commercial market, such as 9-mm, are procured outside the organic base.

Alliant Techsystems recently won a five-year production contract for most of the Department of Defense's small arms ammunition requirements. (See contract award #DAAA0999D0016, posted August 4, 1999.) The solicitation for small arms production was significant in that it required the contractor to bid on the ammunition production requirement and provide a plan for Lake City AAP. The RFP ostensibly made the two requirements independent; for example ammunition production could be done at a location other than Lake City AAP and the plan could offer a strategy for the Army to close Lake City AAP. The reality, however, was that small arms production was expected to be at Lake City AAP and so was bundled with the running of the plant. (The small-caliber ammunition solicitation is posted at <http://www.ioc.army.mil/ac/aaais/ioc/solinfo/sow/sow.htm>.)

Small arms ammunition production is big business in the United States and the military's requirement represents only about one-tenth of the roughly 5 billion round annual production. The industry is dominated by eight

companies, including those producing for the government.⁸⁹ The recent competition that Alliant won was made full and open, potentially allowing U.S. military market access to global competition. As would be expected in such a fundamental military requirement, small arms ammunition production is, in fact, widespread globally. Total capacity is unknown, but certainly foreign, competitive alternatives exist, should they be desired.

Alliant Techsystems and Primex dominate 20-mm to 30-mm ammunition production. This production is done both in the organic base by Alliant at Radford AAP, and at a private facility in Primex's Marion, Ill., facility. Though not in DoD's organic ammunition base, the Marion facility is on federal land. The production capacity estimates in the PBP for this facility are approximately 34 million rounds, or roughly equal to the capacity in the organic base.

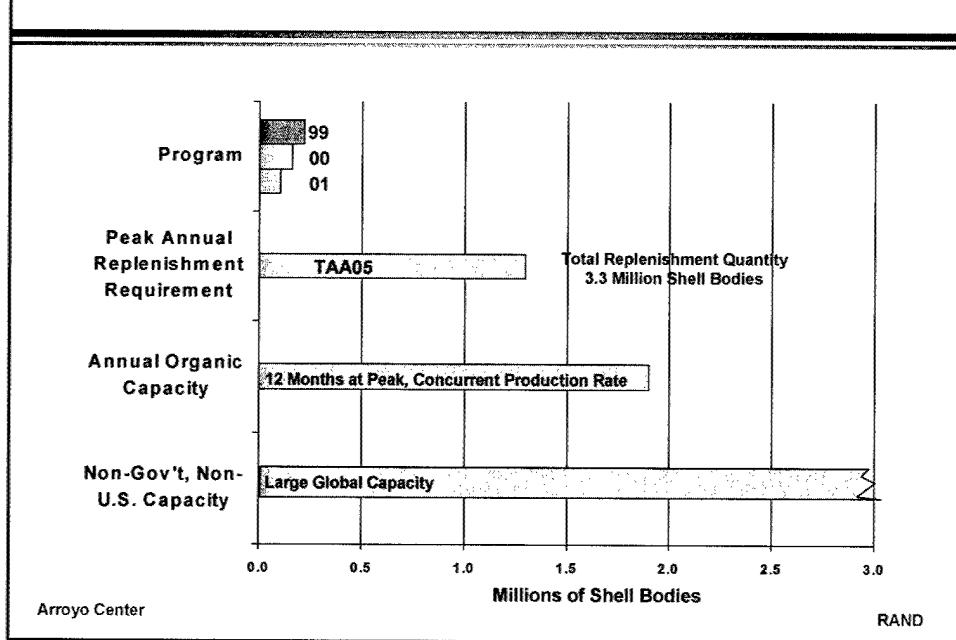
In addition to the domestic capability to produce medium-caliber ammunition, a number of foreign firms produce this ammunition. Total global capacity is unknown but can be presumed to be significant because of the common nature of the medium-caliber ordnance.

Milan AAP provides the planned replenishment capability for 40-mm, though most current and recent production of 40-mm training ammunition has been with several commercial companies, including Martin Electronics, Action Manufacturing, Lance Ordnance, and Dayron.⁹⁰ Total annual training ammunition requirements are fewer than 2 million rounds and whether any of these companies, or a combination of them, could produce the replenishment quantities of warfighting 40-mm ammunition is unknown and problematic. Given the similarities with smaller medium-caliber rounds, however, it is quite possible that Primex or Alliant could produce 40-mm ammunition in their medium-caliber facilities.

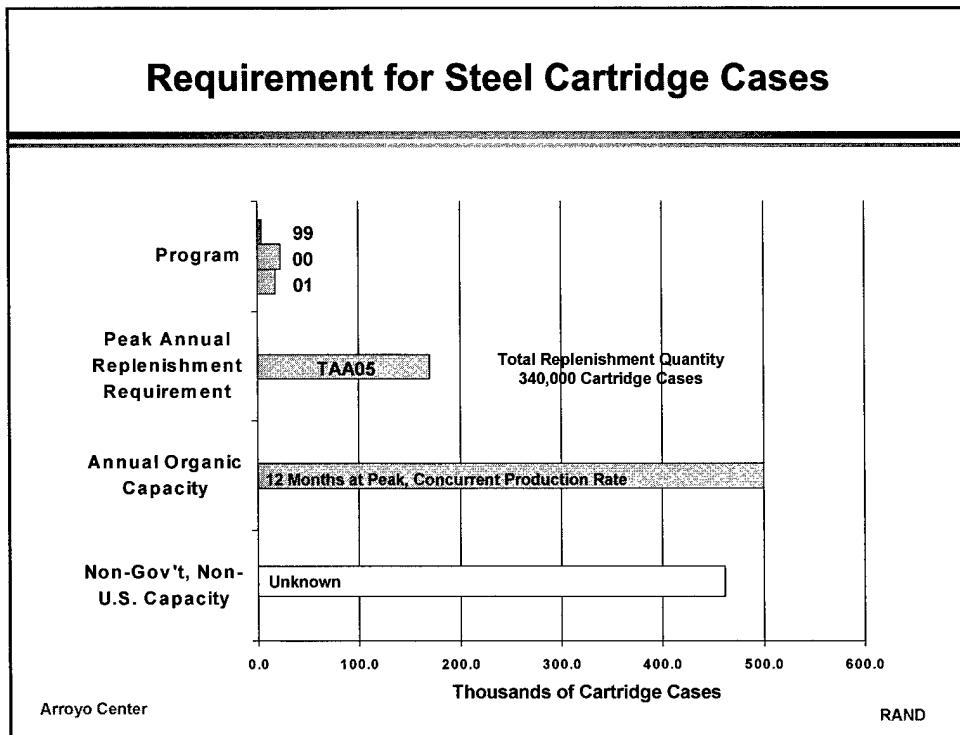
⁸⁹"Small Arms Ammunition Manufacturing," 1997 *Economic Census Manufacturing Industry Series*, U.S. Department of Commerce, U.S. Census Bureau, September 9, 2000, <http://www.census.gov/prod/ec97/97m3329f.pdf>.

⁹⁰Justification and Approval for Other Than Full and Open Competition, Control #CM0990013, Program/Item: CTG 40-mm PRAC M781.

Requirement for Artillery Shell Bodies

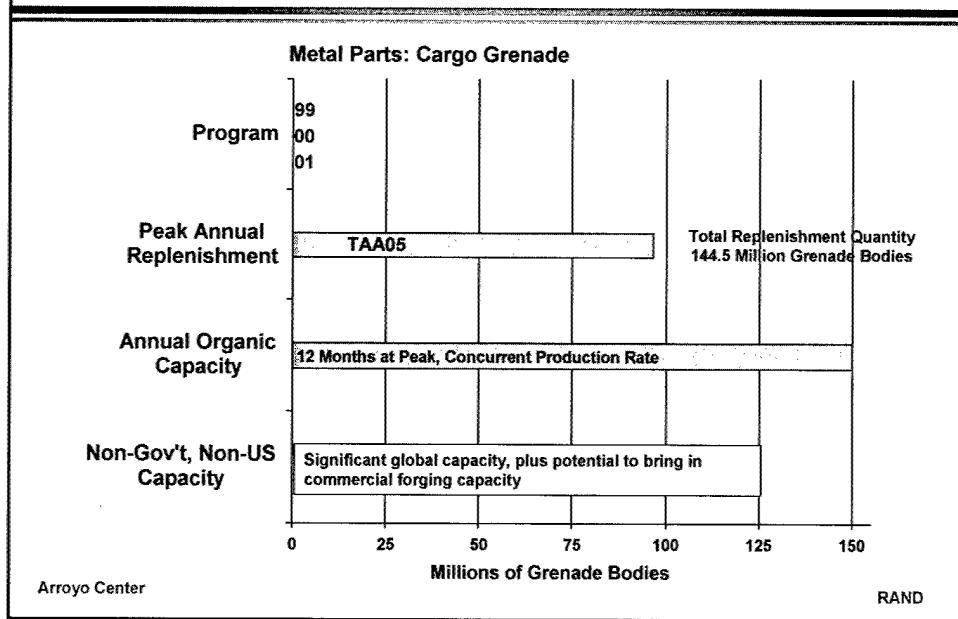


Although a significant replenishment requirement exists for artillery shell bodies compared to current production, available organic capacity as estimated in the PBP appears adequate. Further, the global capacity is quite large.



In the case of steel cartridge cases, the replenishment requirement is very large compared to current requirements, though more-than-adequate capacity is available to handle the replenishment requirement. Current production is several thousand per year, a quantity designed to prove out the production line that was recently moved into Riverbank AAP.

Requirement for Cargo Grenade Bodies



In the case of cargo grenade metal parts, the replenishment requirement is very large, and there is no current production. Capacity appears sufficient, however.

Metal Parts

- **Artillery Shells**

- Peacetime production at Scranton AAP, planned replenishment production also includes Louisiana AAP
- Long stroke forge capability is critical, but very little commercial capability
- Primex (Flinchbaugh) has small capacity
- Unknown overseas capacity

- **Deep-Drawn Cartridge Case (steel)**

- Production at Riverbank AAP
- Long stroke draw capability is critical, but little commercial capability
- Alternate technologies hold some potential (brass, flow form, spiral wrap)
- Unknown overseas capacity

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Current production of artillery shells is at Scranton AAP, which is run by Chamberlain. This facility does not have the capacity to produce the replenishment requirements, and additional capacity at Louisiana AAP is planned. Primex also maintains a capability to meet a small portion of the requirement for artillery shells.⁹¹ Other than Primex, there is little commercial capability in North America to make artillery shells. At issue is the availability of the long stroke forges that make quantity production possible. Though a number of forges across the nation could modify their equipment to provide this capability, a large cost would be associated with the modification.⁹² There is obviously an overseas capability to make these items, but total foreign capacity is unknown and like many of the items previously discussed, the reliability of foreign sources needs assessment.

Deep-drawn, steel cartridge cases are similar to artillery shells: the production limitation being a long stroke draw capability. Currently, few commercial companies have this capability, so replenishment is planned for Riverbank AAP. Potential alternatives exist, however. Brass is a clear

⁹¹Personal discussions with OSC staff at RIA, November 2–3, 2000.

⁹²Mochnal, George F., Director of Research and Education, Forging Industry Association, electronic communication, September 1, 2000.

possibility and is often used to make cartridge cases. To date, however, the items that use steel cartridge cases either have not been certified using brass cartridge cases, or steel offers critical advantages. Flowform and spiral wrap are newer technologies that offer the potential to replace deep drawing of steel. These have yet to prove out in practice, though.⁹³

⁹³Mitchell, John, Norris Industries, during discussions in a meeting a plant tour of Riverbank AAP, Riverbank, Calif., September 28, 2000, and Alan R. Beuster, during discussions RIA, November 2–3, 2000.

Metal Parts (cont.)

- **Cargo Grenades**

- No current production, planned replenishment production at Mississippi AAP, Riverbank AAP. Also at Amron LLC (max capacity of 3 million/year)
- Potential for additional commercial capability
 - Commercial capability for outwardly similar items (forged pistons)
 - Some U.S. forging capability (more than 400 forges), but few, if any, set up for the quantities required in replenishment. Would need to rely on multiple vendors

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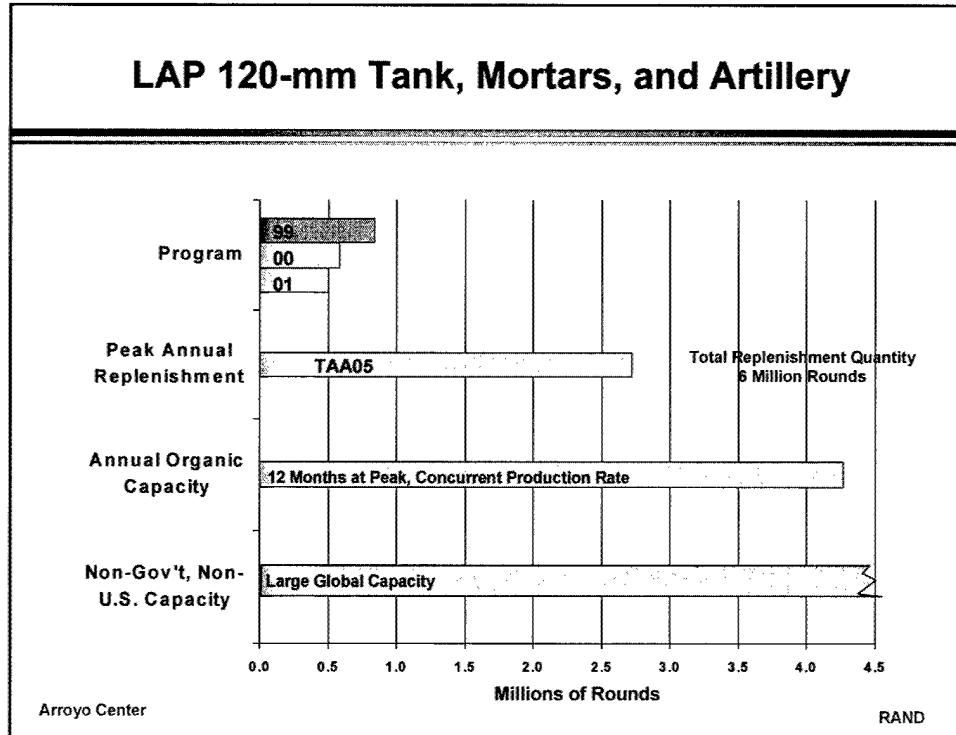
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Despite the lack of current production for cargo grenade bodies, the large replenishment requirement has convinced OSC personnel that two production lines should be maintained, one at Mississippi AAP and one at Riverbank AAP, neither of which are currently in production. Of the six companies that made these items at one time, only Amron, which is making the grenades for a developmental round, continues to make these items outside the organic base.

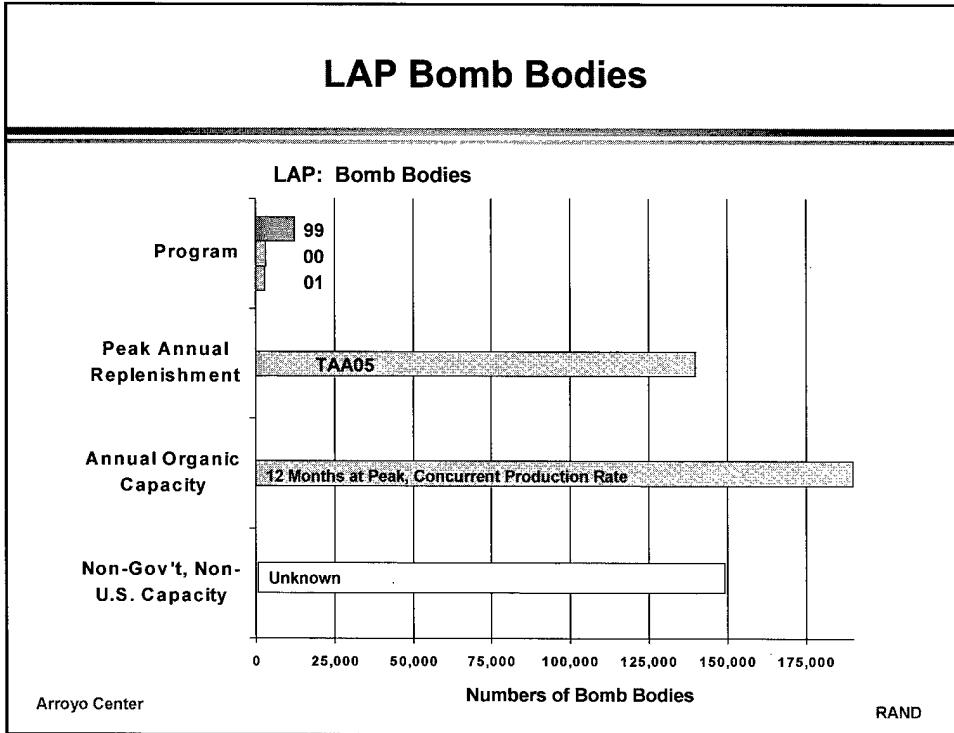
There does appear to be the potential for commercial production. Grenades are reasonably sized and similar items, such as forged pistons, are already commonly produced in the United States. Also, unlike artillery shells, which require specialized equipment, standard, small forging machines are adequate to make these grenades, and there are more than 400 forges in the United States.⁹⁴ Few, if any however, could produce in the quantities necessary for replenishment. A reliance on commercial suppliers for these parts would thus entail contracts with multiple vendors.

⁹⁴"Iron and Steel Forging," 1997 Economic Census Manufacturing Industry Series, U.S. Department of Commerce, U.S. Census Bureau, September 29, 2000, <http://www.census.gov/prod/ec97/97m3321a.pdf>.

LAP 120-mm Tank, Mortars, and Artillery



This figure focuses on the LAP of full-up rounds of ammunition and includes tank, mortar, and artillery shells. In the cases of tank ammunition, the ratio of current to replenishment production is relatively small. This stems from the recurring, large requirement for training ammunition. The ratio is also relatively small for mortar ammunition. This ratio, though, is likely to rise substantially in the next few years. Two types of mortar ammunition dominate current production, and the planned buys of these rounds will be greatly reduced in the future (M888 60-mm HE [high-explosive] and XM934 120-mm HE). The ratio of replenishment to current production for artillery ammunition is substantial. This figure aggregates a number of different items to demonstrate a general adequacy of capacity. As Appendix C discusses in detail, LAP capacity is insufficient to replenish eight items—four 155-mm artillery shells and four miscellaneous items.



Bomb LAP is the last ammunition item we looked at in this report. The difference between current/programmed production and what is planned for replenishment production is very large for bombs. Capacity appears to be adequate to meet the replenishment demands, however. Of note is a shortage in capacity to produce the metal bomb bodies as a LAP ingredient. Appendix C discusses a capacity shortfall for five types of bomb bodies.

Summary

- The market analysis remains a work in progress
- Ammunition production is a more complex issue
 - The private sector can and does provide much of the required ammunition
 - Some items have difficult replenishment requirements. Guaranteeing maintenance of capacity in the private sector may be difficult, but;
 - There is the potential for additional competition in some ammunition sectors

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To date, the market analysis for ammunition has remained a fairly top-level exercise and has yet to be completed. As specific facilities in the organic base are more closely scrutinized and recommendations concerning these facilities are formulated, detailed analyses of each of the items produced at the specific facilities will need to be completed.

That said, the examination to date indicates that the United States already relies to a large extent on the private sector, both on and off government facilities, for ammunition production. This reliance remains constrained, however, because of the existence of replenishment requirements that are large compared to peacetime production. When little or no peacetime production takes place, it is difficult to convince private companies to maintain idle capacity as a contingency against replenishment needs unless the government is willing to pay the costs of maintaining the capacity.

It seems likely that additional potential to introduce further competition for some items exists, though specifics will have to wait for more-detailed work in Phase 3.

APPENDIX C—THE REPLENISHMENT REQUIREMENTS PROCESS

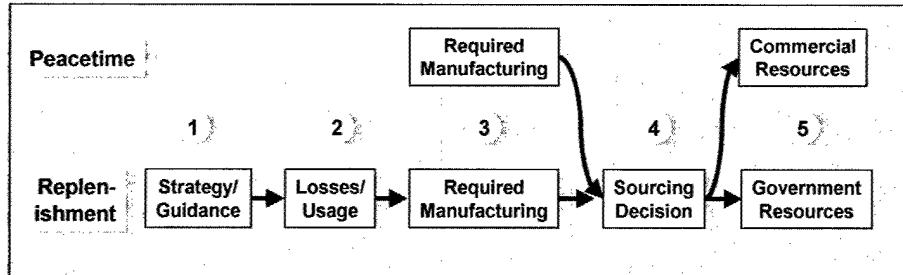
We turn now to the replenishment requirements process. Section Two described the DoD policy of preparing to fight two MTWs, then replenishing one MTW's worth of items consumed. This appendix contains a detailed assessment of both the process by which replenishment requirements are developed and the requirements themselves, concentrating on ammunition.

In summary, the process by which replenishment requirements are determined is slow; the TAA the Army conducted more than a year ago (TAA07) has yet to be processed through the Office of the Deputy Chief of Staff for Operations and Plans, through AMC Headquarters, and converted at AMC's subordinate organization, OSC, into a production base plan that schedules replenishment production. By the time TAA07 requirements are converted into a production plan, a new set of requirements will already be under way.

This figure depicts the five conceptual steps used to arrive at sizing decisions for government-owned production capacity of both ordnance materiel and ammunition. First, the policy provides the principal planning assumptions on the scope, duration, and intensity of anticipated conflicts and the general objectives for industry to support the Army prior to and after wars.

General Process Steps in Ordnance Requirements Determination Process

- Stylized process steps
- Applies to both ordnance materiel and ammunition



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The second step is to estimate how many of what items, such as tanks and artillery pieces, are destroyed and how many spare parts and how much ammunition will be consumed or required during an MTW. To this end, the Army DCSOPS initiates a biennial set of analyses known as the TAA.⁹⁵ The CAA runs a series of both stochastic and deterministic models of the two MTWs that produce estimates of end item losses and rounds of ammunition fired or required in theater. Other services conduct similar analyses and provide the Army with their numbers for common items as well as service-unique items managed by the Army.

Step three involves decisions on how to restore the Army, such as whether the force will be reequipped with the same kinds of items it lost or will more-modern items be procured instead, or if the Army will rebuild a stockpile of spare parts and ammunition similar to the one it had prior to the two MTWs. Answers to these questions for ordnance end items and spares are directed by Army Regulation 700-90, *Army Industrial Base Program*, to be provided by the DCSOPS in the form of a Critical Items List

⁹⁵For a description of the purpose and nature of TAA, see Army Regulation 71-11.

(CIL). Answers for ammunition are governed by DoD Instruction 3000.4, the *Capability-Based Munitions Requirements (CBMR) Process*.⁹⁶

With a set of numbers of critical end items, spares (for Class IX), and ammunition components (for Class V) to be produced, the fourth step is to choose where this materiel will be produced: Will commercial firms (whether contractor-owned and -operated or government-owned and contractor-operated) be asked to produce these items or will government factories get these orders? Finally, there is a determination on which resources to retain at government factories.

⁹⁶This regulation states that “the DCSOPS will approve items selected for planning, and validate requirements for those items; assemble the approved items and requirements into the Department of the Army Critical Items List (DA CIL), which becomes the basis for IBP [Industrial Base Planning]; publish the DA CIL biennially by 1 January.” Headquarters, Department of the Army, AR 700-90, *Army Industrial Base Program*, Washington, D.C., April 1, 1992, paragraphs 1–8.

Assessment of the Ordnance Requirements Process

- Slow—for ammo, TAA05 requirements are current basis for planning; TAA07 analysis at least a year away
- Lacking in discipline: last official critical items list, TAA03
- Unstable from year to year: varying assumptions, program changes
- **Conservative assumptions yield generous requirements:**
 - Wait until completion of MTWs before beginning replenishment
 - Replenish each item to highest MTW usage
 - No returns from theaters
 - No existing CONUS stocks available for replenishment
 - All services assume toughest warfighting scenario

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There are several areas of concern in the process for developing requirements described on the preceding figure. For one, the process is lengthy. On the ammunition side, production planning estimates are prepared on a two-year cycle. The current estimates are based on amounts of ammunition established during the preparation of the FY00–05 program, which occurred more than two years ago. Production planning using the most recent FY02–07 program is to be completed in fall 2001. While the CAA initiates this lengthy process, most of the elapsed time occurs subsequent to its analysis.

Other concerns are the lack of discipline in the process and product variability from year to year. As stated above, AR 700-90, *Army Industrial Base Program*, directs the DCSOPS to prepare a CIL for industrial base planning on a biennial basis. The most recently published CIL was prepared during the FY98–03 budget, which means that two subsequent CILs have been left undone. In the place of these CILs, other, nonstandard lists of requirements have been prepared. As for the variability of the product, Table C.1 shows process output for ordnance end items.

Table C.1
Sample of Ordnance End Item Amounts Estimated in
TAAs 03-07

Nomenclature	TAA03	TAA05	TAA07
Howitzer, 155-mm, Towed	72	38	10
Howitzer, 155-mm, PS	152	83	79
Howitzer, 105-mm, Towed	1	4	1
Tank, Combat, 120-mm Gun	52	6	5

One sees that although the trend in losses generally declines from TAA03 through TAA07, sometimes loss numbers do increase, as was the case with 105-mm towed howitzers. Changing scenarios and operations plans contribute to variation from one TAA to another. (Variability in ammunition numbers is shown in succeeding figures.)

A final, overarching concern with this process is that several of its assumptions are conservative and thus yield generous requirements numbers. First, some overlap is likely in the Phased Threat Distribution used as the basis for each service's combat modeling (most notably between the Army and Marine Corps) such that a net overstatement of some portion of the total requirement may occur. Second is the policy assumption to replenish each end item, part, or ammunition to its highest MTW's usage, as opposed to using the average amount of the two MTWs.

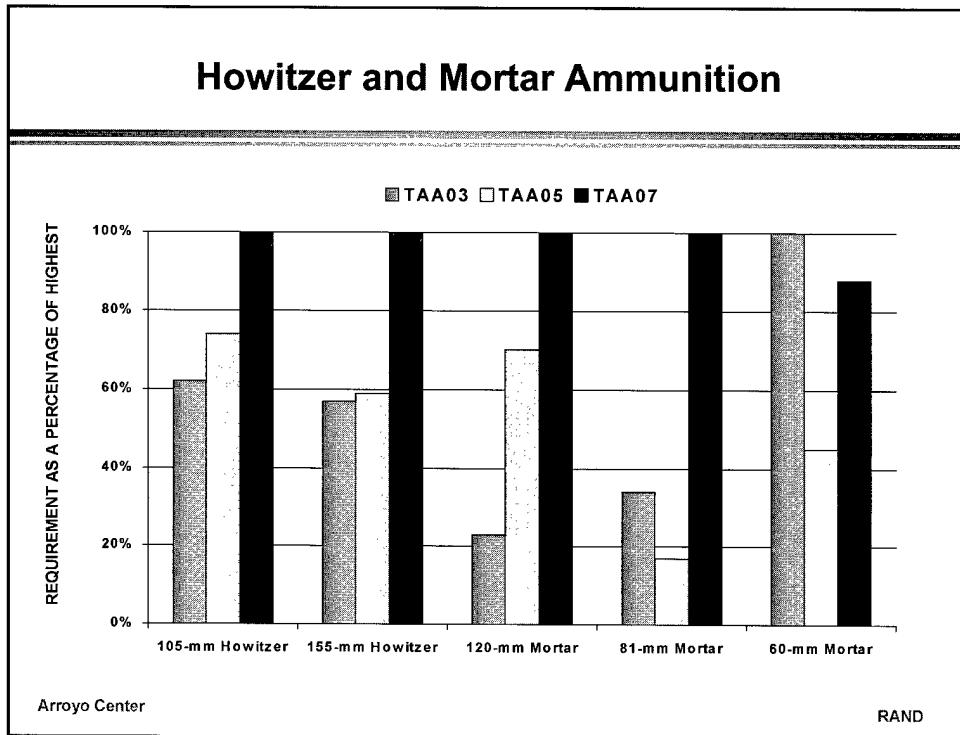
Two assumptions apply only to ammunition requirements. First, that no serviceable rounds will be available in the continental U.S. (CONUS) stockpile above the wartime needs during the planning year (last year of current POM period) because of the gradual deterioration of items over time and to the low level of ammunition surveillance and maintenance funding in the Army budget.⁹⁷ The second ammunition-unique assumption is that no serviceable returns from the warfighting theaters will occur, which in effect says that all munitions sent overseas are expended. This assumption ignores the fact that in some cases a large fraction of the combat requirement number is for stocks to fill the theater supply pipeline and therefore not fired, and perhaps never even removed from their depot-level packaging.

⁹⁷This argument appears in the AMC's *Munitions Functional Area Analysis Reference Book for FY2000*, dated July 2000.

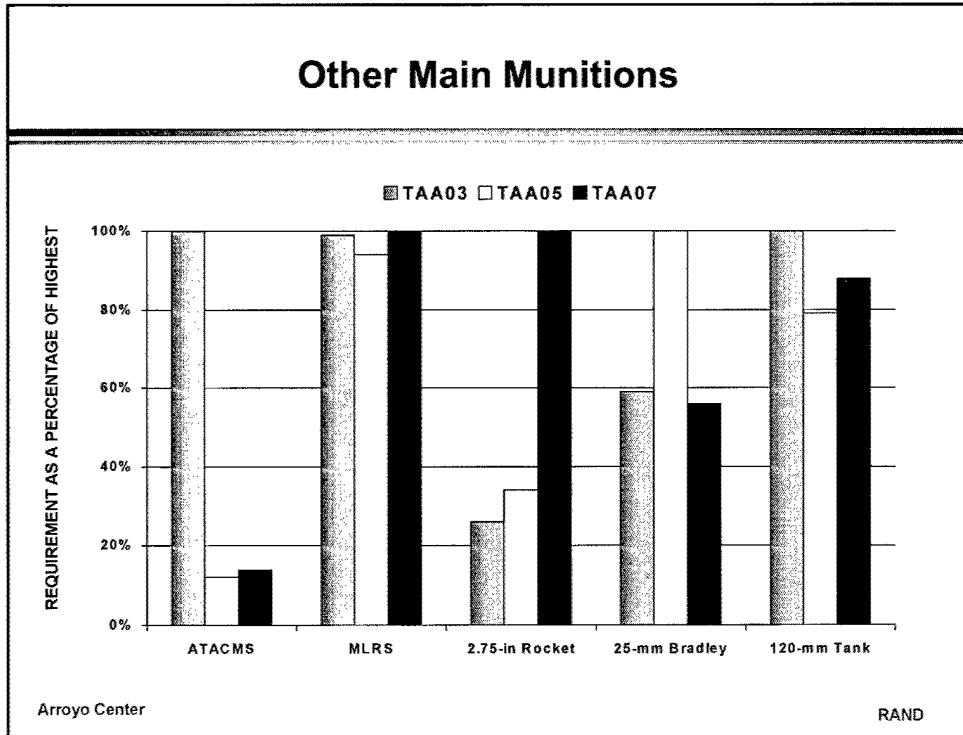
The last conservative assumption is that the industrial base will wait until the completion of the two MTWs before it begins replenishment activities. Further, the planning assumes a cold base (one requiring production and administrative lead time) even for items produced in peacetime, although OSC personnel report that this assumption will be changed in the next version of the production base plan. These assumptions have the effect of reducing the time available in which to meet the replenishment goal of having one MTW's worth of losses manufactured within three years after the completion of the MTWs.⁹⁸ A prudent person could posit an alternative assumption in which replenishment activities—such as ordering raw materials, interviewing additional workers, and purchasing more machine tools—could all be initiated simultaneously with the conduct of the first MTW. This alternative assumption would have the effect of increasing the replenishment period by several more months beyond the 36-month goal.

We recommend that the entire set of assumptions that undergird the replenishment requirements process be assessed and rationalized.

⁹⁸This three-year goal, as mentioned earlier, now applies only to nonammunition items.



The point of this and the next figure is to document some of the variability of the replenishment requirements determination process as it applies to ammunition. This figure compares the Army combat requirements for howitzer and mortar ammunition generated as a part of TAAs 03, 05, and 07 (shown side-by-side). The basic two-MTW scenarios underlie all three of these analyses, but many assumptions about U.S. and opponent force capabilities are changed. In particular: the kinds of weapons and munitions assumed to be available in each of those outyears of the POM, opponent force capabilities, DoD-directed MTW sequencing, and the levels capabilities, combined with the elimination of previously planned for friendly force artillery autoregistration enhancements and the Sense and Destroy Antiarmor round (because of lack of funding in subsequent [07] POM), account for the increased consumption of large-caliber mortars. The fluctuations are driven by changes across TAA runs in the mix of heavy and light divisions assigned to each MTW. These year-to-year fluctuations, while perhaps unavoidable, contribute to instability in procurement actions, which, in turn, reduces efficiency of producers.

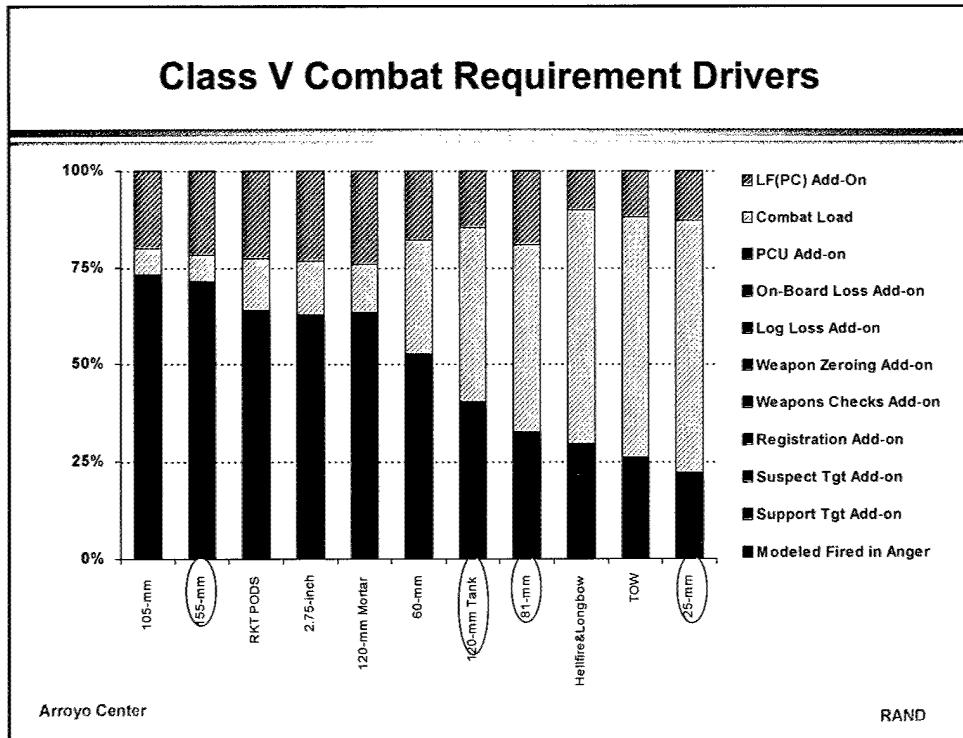


This figure shows the variability of replenishment requirements for five additional important munitions. Not only are there great differences from year to year, but no overall pattern of general, across-the-board increases, decreases, or substitution appears within this group. For example, direct fire munitions, such as 25-mm and 120-mm, do not rise or decline in parallel over the three periods. The high analysis year for 25-mm was TAA05, while that same year was the lowest of the three for 120-mm.

This line of reasoning is not intended as a critique of CAA's combat modeling. For each TAA, these models must incorporate a host of changes in starting assumptions, scenarios, and friendly and opponent capabilities that lead to valid estimates for ammunition requirements that have significantly shifted up or down over time.⁹⁹ However, the way Army industrial planners use these combat model estimates creates a situation in which problems can arise. Any significant change in the ammunition requirement from one TAA to the next can create a whipsaw effect on the industrial base. Particularly in the case of a round that may have capacity

⁹⁹The Army Tactical Missile System (ATACMS) estimate is a prime example. Budget expectations in the TAA03 analysis were optimistic. The two subsequent TAAs incorporated an ATACMS budget constraint, which resulted in a greatly reduced estimate for these missiles.

difficulties—such as the 25-mm—a near doubling of the requirement from TAA03 to TAA05 could cause planners to direct a large amount of resources toward improving that capacity only to find two years later with TAA07 that the newest requirement is back down to the range it was four years earlier, perhaps leaving the industrial planners with excess capacity.



The stacked bars in this figure represent the total combat requirements for the two MTWs and show the ratio of rounds consumed (solid colors starting from the bottom up) to those carried on the vehicles or present elsewhere in theater to fill the logistics pipeline (the two sections of bars from the top down with hashed fills). One sees that the projected amount of ammunition consumption as a percentage of the total combat requirement depends on the role of the ammunition. Indirect fire systems, on the left side of the figures, are expected to fire many times their combat load during a campaign in support of maneuver forces (indirect fires are expected to kill or incapacitate opposing forces and to also conduct missions to suppress and harass). Thus, at the extreme left, about three-quarters of the combat requirement for 105-mm howitzer rounds are anticipated to be expended in theater and about a quarter carried by the units or in the theater pipeline.

To the right on the figure are direct fire systems, with an opposite pattern of expenditure. On the extreme right, about one-quarter of the TOW missile and 25-mm gun combat requirement is expected to be fired, with the remaining three-quarters either still carried by units or in the theater pipeline.

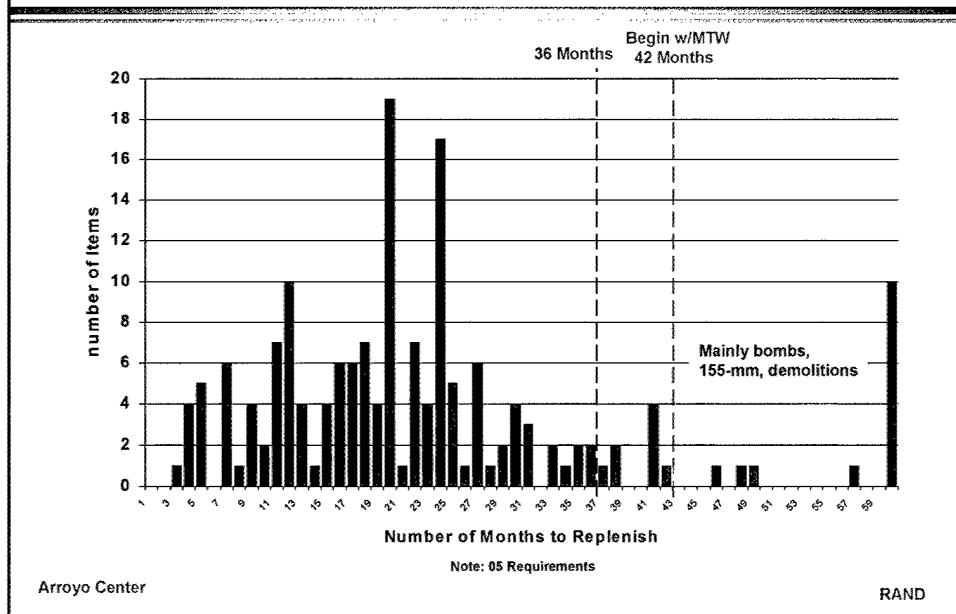
The amounts of the ammunition requirement estimated to be not expended provides an opportunity to partially address anticipated difficulties in

meeting the DoD's replenishment guidance. Certainly, much of this unexpended ammunition may be lost, destroyed, or damaged—but not all. For some of the items identified in the TAA05 industrial base analysis as being difficult to replenish in the 36-month timeline—155-mm, 120-mm tank, 81-mm mortar, and 25-mm (circled)—the replenishment requirement may be partially offset by either the theater logistics pipeline stocks, or by unit combat loads, or both.¹⁰⁰

¹⁰⁰ Some may argue that large amounts of the ammunition issued to troop units and then returned unexpended will be unusable because at the end of Operation Desert Storm these returns were in such poor condition that extensive surveillance and maintenance would have been needed to return them to usable status. This historical anecdote is certainly true, but, to our knowledge, no documentation of the extent of this ammunition degradation exists. Countervailing evidence should make one pause before applying the degradation anecdote to all munitions issued but not fired in a theater: At the end of Desert Storm, hundreds of thousands of rounds were either aboard ship or in the theater pipeline—rounds still in their depot packaging and likely still in usable condition.

So, if in the future the Army has conducted two MTWs and is suddenly faced with a third, a prudent person would search for any existing source to meet the demand. If an additional MTW's worth of 25-mm ammunition were not sitting in wholesale storage, one imagines that thousands of 25-mm rounds sent to the first two MTWs but not expended would be quickly identified, inspected, and moved to where needed to meet the MTW demand. It is difficult to imagine the wholesale base informing the combatant commander that he will just have to wait for the production base to make new 25-mm rounds.

149 of 171 Planned Ammunition Items (87%) Can Be Replenished Within Three Years



This figure displays the estimates for the number of months to complete the ammunition replenishment requirement amounts determined during the FY00–05 POM period, including all services' requirements for planned items.¹⁰¹ The number of individual ammunition items is displayed on the vertical axis and the number of months along the horizontal axis. For example, the bar with a height of six above the tick mark for eight months' time to replenish indicates that there are six munitions that can be made in sufficient quantity to meet their replenishment requirement by the end of the eighth month. So, of the 171 items for which OSC prepares a formal plan, this graph shows that 149 can be made within 36 months (the combined heights of the bars to the left of the red dotted line that indicates the end of 36 months). This leaves 22 items that exceed 36 months' production time. If one assumes that production could begin at the beginning of the first MTW—rather than six months later as is currently the case—the entire schedule effectively shifts to the left allowing another eight items to be completed within the three-year period (eight more items fall to

¹⁰¹As the single manager for conventional ammunition, OSC tracks roughly 455 ammunition items. Of these, the 171 shown on this chart are deemed to require formal production planning and the source document for the estimates of the time needed to produce their replenishment amount is OSC's *SMCA Production Base Plan* as of September 22, 1999.

the left of the dotted gray line that indicates the end of 42 months). This leaves 14 items that cannot be made within the three-year limit, mainly aircraft bombs, 155-mm howitzer shells, and some mines and demolitions.

Pacing Item or Process for Items over 36 Months: 60% Components, 40% LAP

DODIC	Pacing Item	Nomenclature
C870	LAP (Pressing)	CTG 81MM SMK SCREEN RP M819
K143	COMP C4 Fill	MINE AP M18A1 CLAYMORE W/ACCESS
M023	COMP C4	CHG DEMO BLK M112 1.25 LB COMP C-4
M757	COMP C4	CHG ASSY DEMO M183
M913	COMP C4	CHG DEMO FLEX LINEAR M58A3
ML25	COMP C4	CHG LINEAR HE (C4) M59
EA02	Metal Parts	BOMB PENE 5000 LB BLU-113A/B TRIT
F140	Metal Parts	BOMB PENE 2000 LB BLU-109/B TRIT
F289	Metal Parts	BOMB GP 1000 LB BLU-11CA/B PBX
F289	Metal Parts	BOMB GP 500 LB BLU-111/B PBX
E485	Metal Parts	BOMB GP 500 LB MK82-1 TRIT
C792	Sabot	CTG 120MM M829A2 APFSDS-T
D702	Safe & Arming Device	PROJ 155MM RADAM-S
D529	LAP	PROJ 155MM HE M795 TNT W/O FZ
D544	LAP	PROJ 155MM HE M107 COMP B W/O FZ
D579	LAP	PROJ 155MM HE RAP M549A1 TNT LDD
D061	LAP	PROJ 155MM M898 SADARM
MN28	LAP	SELECTABLE LIGHTWEIGHT ATTACK MUNITION M94
HZ01	LAP	WIDE AREA MINE XM93 (WAM)
A986	LAP	CTG 25MM APFSDS-T M919
EWAA	LAP	FLARE IR DECOY MJU-27A/B
	Unknown Capacity	M234 FUZE, SELF-DESTRUCT (MLRS-M77 GRENADE)

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For the 22 items that cannot be produced in the 36-month replenishment window, this figure shows the source of delay. For nine of these the bottleneck is the capacity of the LAP production lines planned for replenishment. Many of these lines could make enough of the particular item if they were exclusively producing that item; however, they are planned for multiple items of production over the replenishment period, so their effective rate is reduced. For the other 13 items, a component is the bottleneck.

These range from blocks of composition C4 to metal bomb bodies to composite discarding sabots. Finally in the case of last item listed above—the M234 self-destruct fuse that goes into the M77 submunitions grenade in the MLRS rocket—this is a commercially produced item, but the capacity in the commercial sector is unknown.¹⁰²

¹⁰²OSC suggests that there is but a single, commercial, producer of this developmental item.

Near-Peer Scenario

- Last European scenario done before adoption of two-MTW planning
- About a two-month campaign against former Soviet-bloc forces in Eastern Europe
 - Uses TAA01 Force Structure
 - U.S., allied, and opponent forces greater in size than either of the current MTWs:

<u>U.S.</u>	<u>Former Soviet-Bloc</u>
• 5 Mech Divisions	• 17 Motorized Rifle Divisions
• 2 Armor Divisions	• 5 Armor Divisions
• 2 ACRs	• 3 Airborne Divisions
<u>Allies and Partners</u>	<u>reinforced by</u>
• 16+ Divisions	• 4 Motorized Rifle Divisions
	• 3 Armor Divisions

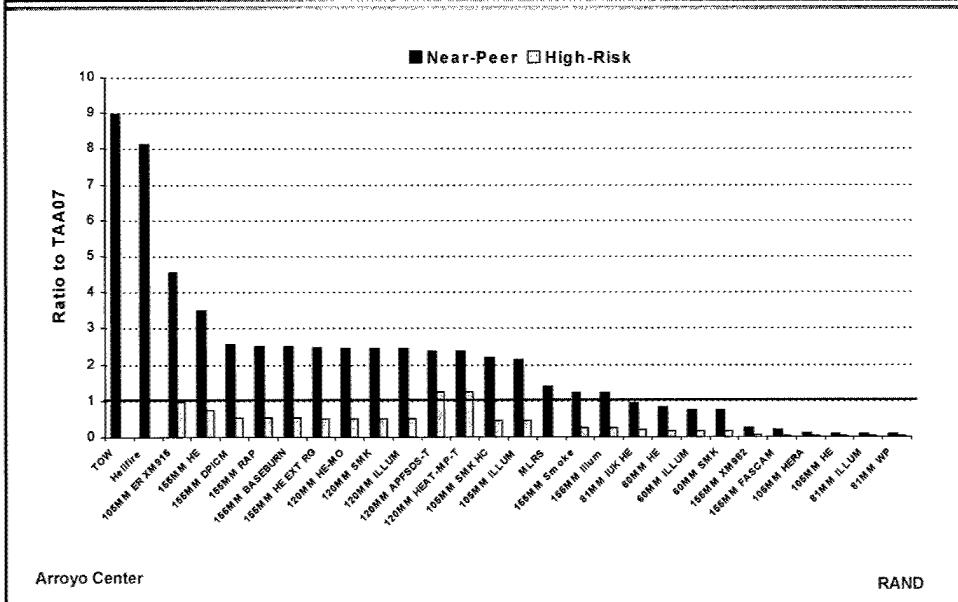
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The near-peer scenario outlined in this figure was considered for the purpose of comparison of the results of its assumed tougher conflict against the results of the two-MTW planning scenario. Because of the long lead times for the CAA to prepare and run a contemporaneous near-peer analysis, an older, archived scenario and its results were used.

This old scenario was created after the end of the Cold War but prior to the adoption of the two-MTW defense strategy. It posited a single conflict of roughly two months' duration on the North European plain between former Soviet-bloc forces and NATO and coalition partners. The Army's participants were two corps, totaling seven heavy divisions with the weapons and force structure assumed to be available by 2001 (about seven years in the future at that time). This U.S. force was supported by 16-plus Allied and coalition divisions and faced 24 Soviet-style motorized and armored divisions, with another three airborne divisions, reinforced by seven more heavy divisions. The specific details of this conflict simulation are classified and not needed to understand the major points that the force totals on both sides were significantly larger and that both sides had much more comparable technological capabilities than is the case in either of the MTWs considered in contemporary planning.

“Near-Peer” and “High-Risk” Arranged by Ratio to TAA07 (Army) Projected Consumption



The results of the “near-peer” (and “high-risk”) analysis are shown as a ratio to two-MTW scenario replenishment amounts, round-for-round.¹⁰³ Thus, a bar that reaches to one on the vertical axis (highlighted by a red line) indicates that that particular round is estimated to have the same need in both the near-peer and two-MTW cases. What is apparent in this figure is that, for more than half of the rounds considered, the single-conflict near-peer case estimates projected consumption amounts significantly greater than in the two-MTW scenario. If these numbers were part of a replenishment planning paradigm, then one might be quite concerned about industrial capacity to make these numbers of rounds during the 36-month time frame. But the near peer is not found in the current policies, so this raises the question of a different planning paradigm for this scenario, such as the stockpiling or surge, as was more the case during the Cold War.

The second, lower set of bars indicate the ratio of the high-risk scenario to the two-MTW requirements, again round by round. (The high-risk variant to the TAA07 analysis was created to estimate changes to U.S. losses in a

¹⁰³This chart is based on the “projected consumption” amounts for the near-peer, high-risk, and two-MTW cases. Comparisons of the “combat requirements” of these scenarios may yield somewhat different ratios, but the combat requirement amounts for the near-peer case was unavailable.

theater in which friendly air capability is reduced thus increasing—presumably—the risk to the ground forces.) In contrast to the near-peer results, for only three types of rounds are the estimates for munitions amounts equal to or greater than the TAA07 estimate. This may at first seem counterintuitive as the high-risk is a tougher fight of a TAA07 scenario. But the comparisons are accurate because the high-risk scenario considers only one theater's projected consumption, while the policy for the two-MTW replenishment numbers is to select the higher MTW's amounts, round by round.

What We Know of Capacities To Meet Replenishment Requirements

- **Ordnance items (WVA and RIA)**
 - Sufficient capacity to meet even much larger than anticipated requirements (Phase 1 analysis)
- **Ammunition**
 - 433 of 455 items can be replenished within three years (TAA05 requirements); most within 24 months
 - Principal constraints: bomb bodies, Comp C4, LAP (mainly 155-mm), fuzes
 - Near-peer requirements could tax some capacities—but there are options

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Assessing the replenishment numbers, the requirements for ordnance end items and spare parts are well within existing capacity and can be met within the 36-month replenishment period.

As for ammunition, most of the needed items—284 of 455—are not planned for, meaning that there is no apparent concern about their availability post-MTW. For the remaining 171, industrial planning shows that all but 22 could have replenishment quantities completed within the 36-month planning time. The production constraints for these 22 are split almost equally between component parts availability (penetrator bomb bodies, fuzes, and Composition C4) and LAP capacity (mostly a 155-mm LAP constraint). The near-peer (tougher conflict) scenario could tax some production capabilities, but some options could ease this strain and the two-MTW replenishment shortfalls that will be further discussed in succeeding figures.

Options for Dealing with Capacity Shortages

- **Reassess assumptions underpinning requirements:**
 - No returns from theater, any additional rounds in stockpile will be unserviceable
 - Highest MTW usage
- **Invest in improved conventional munitions**
 - Substantially reduces requirement as well as footprint
 - Improves outcome of warfighting
- **Begin replenishment as MTWs commence**
- **Buy expanded manufacturing capacity**
- **Stockpile pacing items during peacetime**

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This figure lists some of the options available to ease that apparent capacity shortfall, three that could be said to address the requirements or demand for ammunition and two that would affect the production capacity on the supply side. On the “demand” side of the replenishment equation, one could start with a reassessment of two important assumptions: first, that no rounds would return from either MTW in a usable condition, and second, that no rounds above MTW requirements that may be in the worldwide stockpile would be serviceable. It may prove much easier and faster to perform some surveillance and maintenance on these quantities of munitions than to produce the entire replenishment quantities. Another potential way to reduce the demand for rounds is to invest in improved conventional munitions, which may substitute for several conventional rounds thereby lowering the overall warfighting requirement (particularly in the case of indirect fire weapons).

On the “supply” side, a simple policy change—that of beginning replenishment actions at the start rather than at the completion of the two MTWs—could add several months to the time available to produce the replenishment quantities. Beyond this simple policy change, the Army could invest in additional manufacturing capacity and stockpile some of the pacing items, such as penetrator bomb bodies, in peacetime.

Conclusions

- Requirements

- A lot of uncertainty of what would actually be required postconflict
- Inflated (large part of requirement determined by safe-sided factors)

- Capacity

- No apparent capacity problems for end items or spare parts considered
- Also, the vast majority of ammunition can be made within a three-year period (433 out of 455 items considered)
- But of the 22 remaining ammo items, there are some mitigating factors:
 - start replenishment on warning (adds six months to the timeline)
 - four important rounds—155-mm, 120-mm, 81-mm, 25-mm—could be offset to some extent by returns from theater
- Otherwise, most items complete within 24 months (or 30 months) so there arguably is slack capacity throughout the ammunition base

Generally optimistic that replenishment requirements can be met with existing capacity

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In summary, for this appendix, the true needs of future conflicts remain highly uncertain and our best estimates of those needs for the conflicts posited by DoD may be fairly safe-sided. As for capacity to meet those arguably robust requirements, there appears to be no general shortage in capacity for ordnance end items and spare parts. Most ammunition items, too, can likely be produced within the three-year replenishment period. Of the remaining few important ammunition items that fall outside the time frame, some options exist for relieving some of the shortages, and generally within the ammunition production base (both commercial and government-owned) there appears to be some slack capacity over the replenishment time frame as most of the planned items are completed in two years or less.

We offer two recommendations for improving process by which replenishment requirements are developed. First, we recommend that an ad hoc Headquarters, Department of the Army, review panel assess the assumptions that underpin the resulting requirements. Second, we recommend that this panel seek ways to streamline and accelerate the process.

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